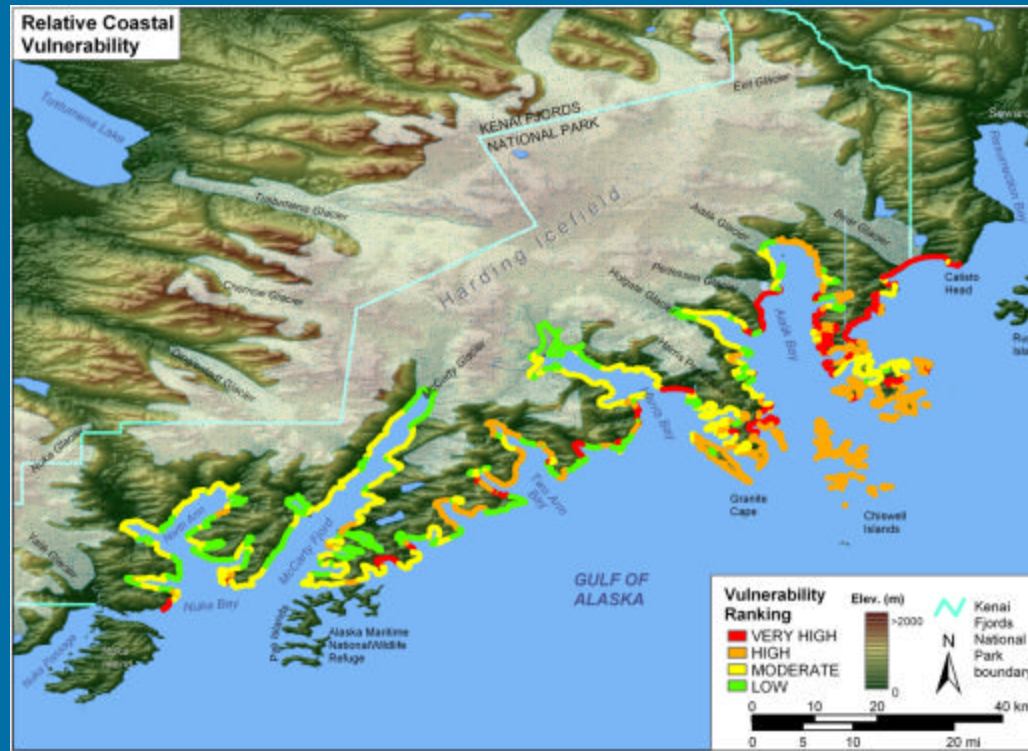


Vulnerability of Coastal Parks to Sea-Level Rise



Kenai Fjords NP

Rebecca Beavers, Ph.D.

NPS Geologic Resources Division



Coastal Change



Outline

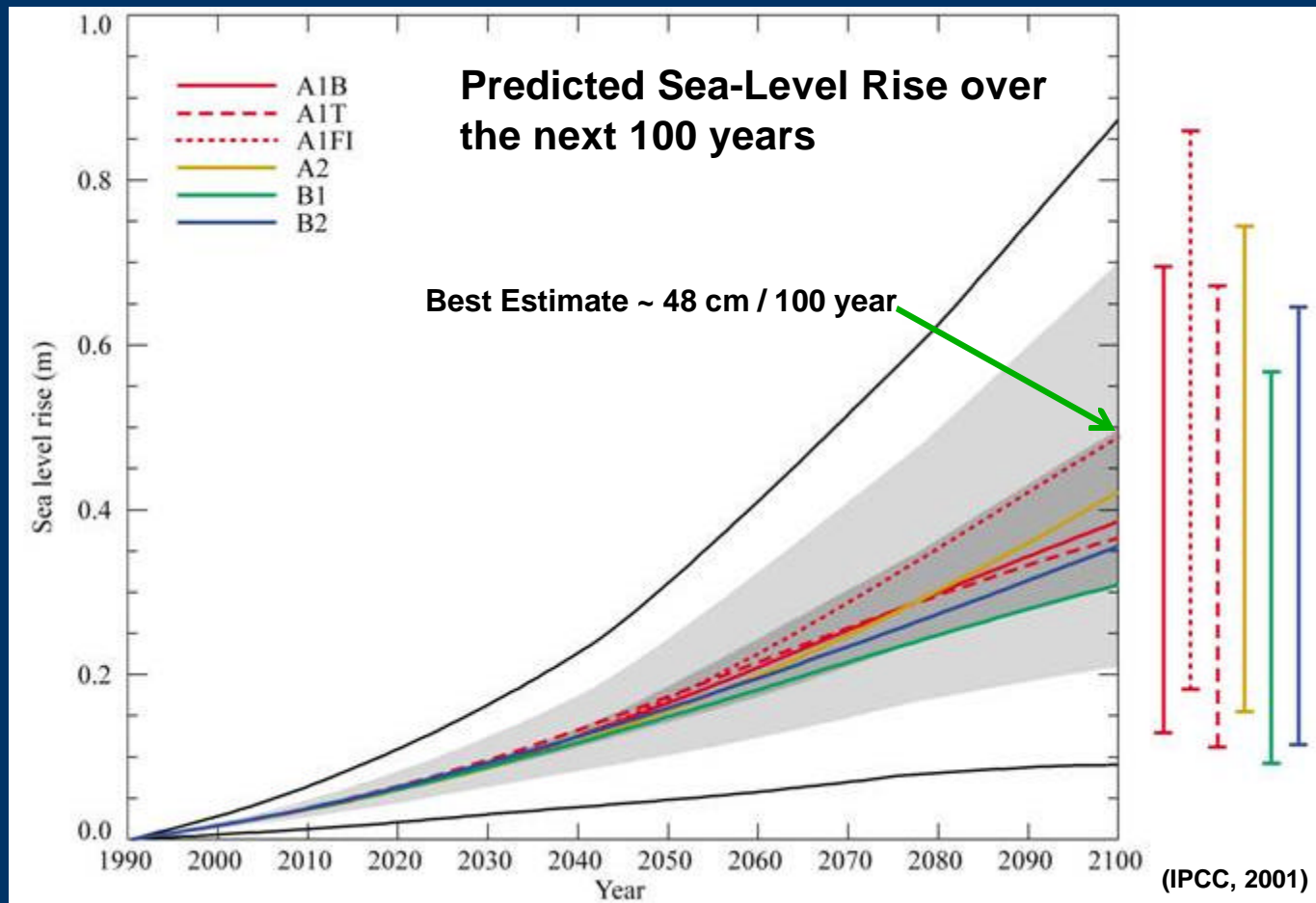
CVI Methods

Parks:

- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

Digital Products

Motivation for sea-level rise research



Coastal Vulnerability to Sea-Level Changes

- ➔ **Relative Sea-level**
- ➔ **Wave Heights**
- ➔ **Tide Range**
- ➔ **Coastal Erosion Rates**
- ➔ **Coastal Slope**
- ➔ **Geomorphology**



Gulf Islands NS

National Assessment of Coastal Vulnerability to Sea-Level Rise

E. Robert Thieler, Jeff Williams, Erika Hammar-Klose



Atlantic Coast

Pacific Coast

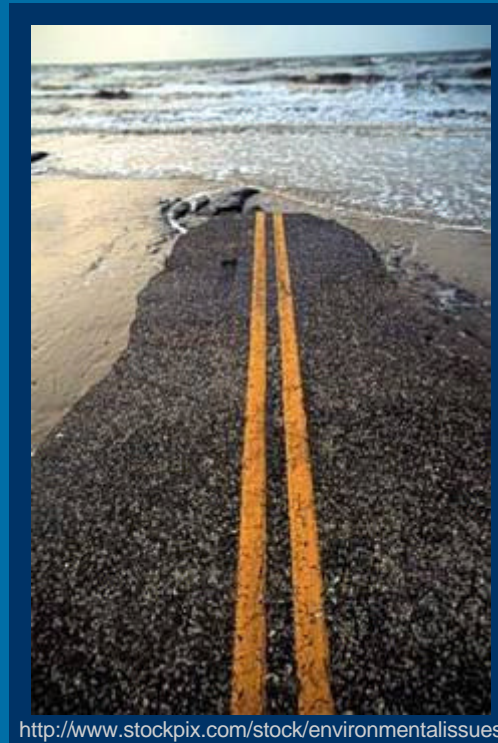
Gulf Coast

Relative Coastal Vulnerability of National Park Resources to Sea-Level Rise

■ Elizabeth A. Pendleton, E. Robert Thieler, S. Jeffress Williams, Rebecca L. Beavers, and Erika S. Hammar-Klose

Motivation

- The rate of eustatic SLR is expected to accelerate based on studies considered by the IPCC.
- The best estimate of SLR rate for the 21st century is 4.8 mm/yr; this is more than double the rate for the past 100 yr -- 1.8 mm/yr.



Objectives

- Highlight areas where coastal change as a result of sea-level change may be most likely to occur.
- Provide NPS with a quantitative tool to assist in managing resources that may be vulnerable to SLR.

PROPOSED PARKS FOR COASTAL VULNERABILITY INDEX (CVI) ASSESSMENT

PACIFIC COAST

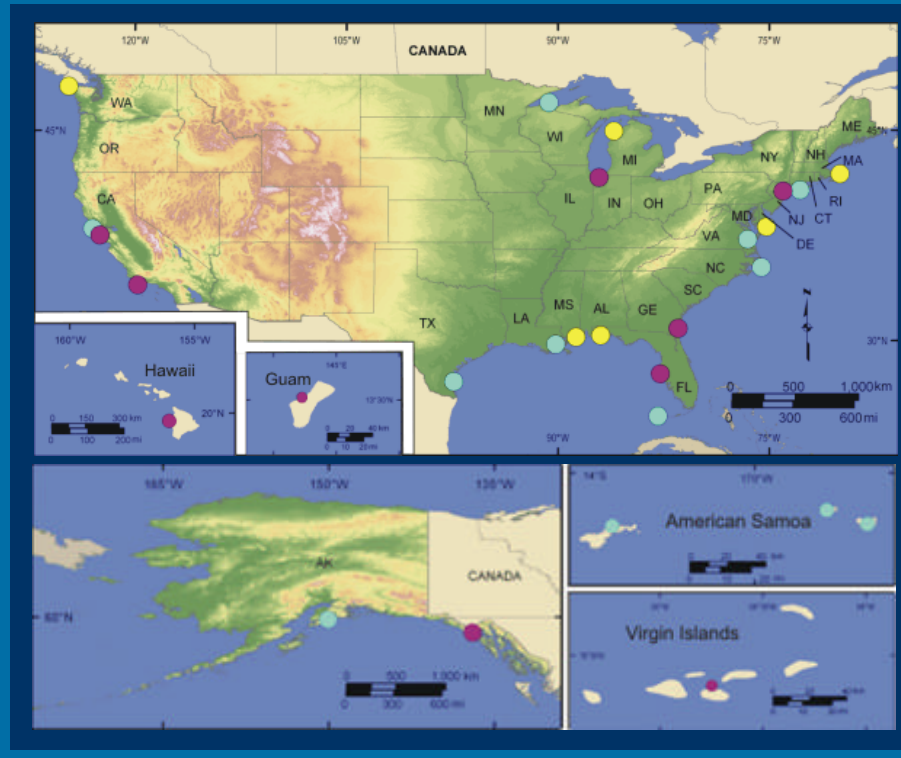
Channel Islands NP
Golden Gate NRA
Olympic NP
Point Reyes NS

ALASKA

Kenai Fjords NP
Glacier Bay NPP

PACIFIC ISLANDS

Kaloko-Honokohau NHP
NP of American Samoa
War in the Pacific NHP



NORTHEAST

Assateague Island NS
Cape Cod NS
Colonial NHP
Fire Island NS
Gateway NRA

SOUTHEAST

Cape Hatteras NS
Cumberland NS
Virgin Islands NP

GULF OF MEXICO

Dry Tortugas NP
Gulf Islands NS
Jean Lafitte NHP
Padre Island NS
DeSoto NM

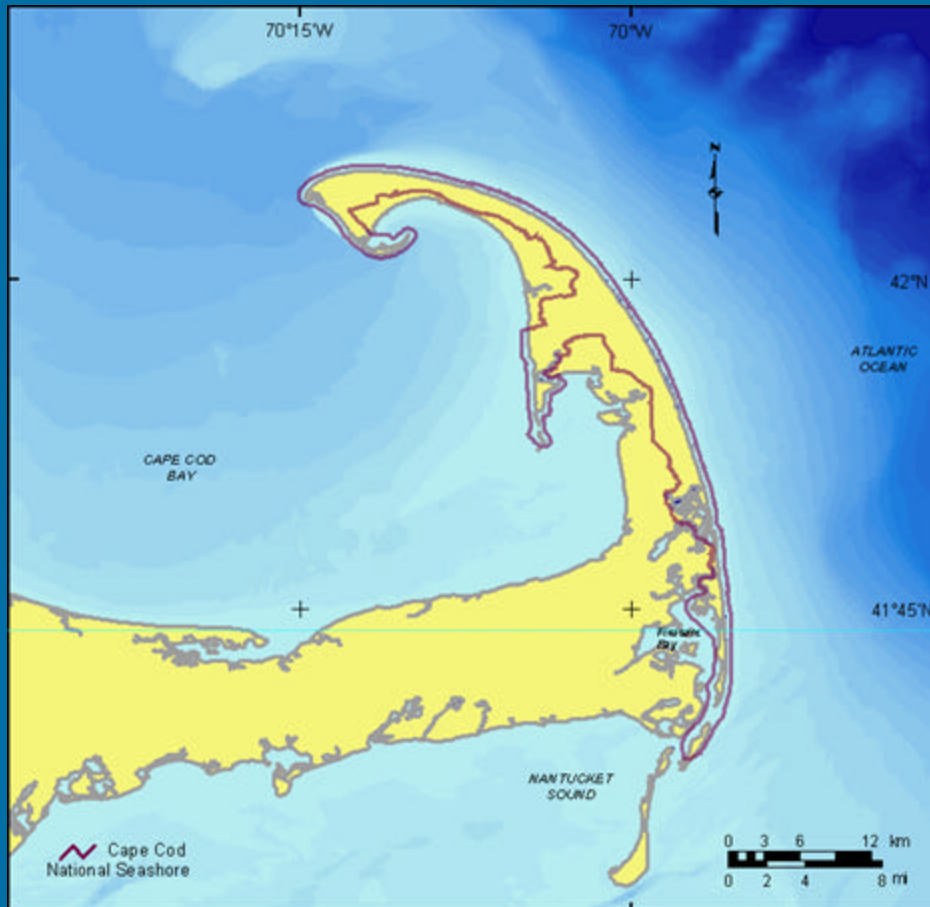
GREAT LAKES

Apostle Islands NL
Indiana Dunes NL
Sleeping Bear Dunes NL

- mapped with USGS funding
- mapped with Fee Demonstration funding
- mapped with NRPP funding



The CVI GIS database





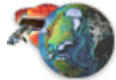










- Acquire high resolution shoreline for the park
- begin joining existing data for vulnerability assessment to the shoreline shapefile

CVI Variables and Sources of Data

Geologic Variables

Physical Process Variables

VARIABLES	SOURCE
GEOMORPHOLOGY	<p>Aerial Photography from MassGIS and USGS</p> <p> </p> <p>http://edcwww.cr.usgs.gov/ http://www.state.ma.us/mgis/</p>
SHORELINE EROSION/ACCRETION (m/yr)	<p>USGS Administrative Report: The Massachusetts Shoreline Change Project: 1800s -1994 (Thieler et al., 2001)</p> <p> </p> <p>http://www.state.ma.us/czm/shorelinechange.htm</p>
COASTAL SLOPE (%)	<p>NGDC Coastal Relief Model Vol 01 12/17/1998</p> <p> </p> <p>http://www.ngdc.noaa.gov/mgg/</p>
RELATIVE SEA-LEVEL CHANGE (mm/yr)	<p>NOAA Technical Report NOS CO-OPS 36 SEA LEVEL VARIATIONS OF THE UNITED STATES 1854-1999 (Zervas, 2001)</p> <p> </p> <p>http://www.co-ops.nos.noaa.gov/publications/techrpt36doc.pdf</p>
MEAN SIGNIFICANT WAVE HEIGHT (m)	<p>North Atlantic Region WIS Data (Phase II) and NOAA National Data Buoy Center</p> <p>  </p> <p>http://bigfoot.wes.army.mil/u003.html http://seaboard.ndbc.noaa.gov/</p>
MEAN TIDE RANGE (m)	<p>NOAA/NOS CO-OPS Historical Water Level Station Index</p> <p> </p> <p>http://www.co-ops.nos.noaa.gov/station_index.shtml?state=</p>

Ranges for Vulnerability Ranking of Variables

VARIABLES	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	1	2	3	4	5
GEOMORPHOLOGY	Rocky, cliffed coasts Fjords	Medium cliffs Indented coasts	Low cliffs Glacial drift Alluvial plains	Cobble Beaches Estuary Lagoon	Barrier beaches, Sand beaches, Salt marsh, Mud flats, Deltas, Mangroves, Coral reefs
SHORELINE EROSION/ACCRETION (m/yr)	> 2.0	1.0 - 2.0	-1.0 - 1.0	-2.0 - -1.0	< -2.0
COASTAL SLOPE (%)	> 1.20 >1.90	1.20 - 0.90 1.90 -1.30	0.90 - 0.60 1.30 - 0.90	0.60 - 0.30 0.90 - 0.60	< 0.30 <0.60
RELATIVE SEA-LEVEL CHANGE (mm/yr)	< 1.8	1.8 - 2.5	2.5 - 3.0	3.0 - 3.4	> 3.4
MEAN WAVE HEIGHT (m)	< 0.55 < 1.10	0.55 - 0.85 1.1 - 2.0	0.85 - 1.05 2.0 -2.25	1.05 - 1.25 2.25 - 2.60	> 1.25 > 2.60
MEAN TIDE RANGE (m)	> 6.0	4.0 - 6.0	2.0 - 4.0	1.0 - 2.0	< 1.0

Atlantic/Gulf Ranges
Pacific Ranges

Coastal Vulnerability Index (CVI) Calculation



X_coord	Y_coord	Gridcode	Landform	Slope	Tide	Sealevel	Waves	Shorchange	Rchchange	Rlslope	Rlgrs	Rlcliff	Rlwave	Rlres	Cvi
-70.07455	41.89225	43	Spit	0.3066	3.04800	1.895	0.90	-0.4352	3	5	5	3	3	2	15.00000000
-70.07455	41.87555	46	Spit	0.2245	3.04800	1.895	0.90	-0.4352	3	5	5	3	3	2	15.00000000
-70.05785	41.87555	47	Spit	0.7836	3.04800	1.895	0.90	-0.4352	3	4	5	3	3	2	13.41640786
-70.07455	41.95905	30	Beach	1.6799	3.04800	1.895	0.90	-0.3572	3	2	5	3	3	2	9.48683298
-70.07455	41.94235	32	Beach	1.4247	3.04800	1.895	0.90	-0.5439	3	2	5	3	3	2	9.48683298
-70.07455	41.92565	36	Beach	0.8514	3.04800	1.895	0.90	-1.0374	4	3	5	3	3	2	13.41640786
-70.07455	41.90895	39	Beach	0.5396	3.04800	1.895	0.90	-0.4352	3	4	5	3	3	2	13.41640786
-70.07455	41.89225	43	Spit	0.3066	3.04800	1.895	0.90	-0.4352	3	5	5	3	3	2	15.00000000
-70.24155	42.07595	2	Low Cliff	3.8527	2.78590	1.895	1.10	0.9734	3	1	3	3	4	2	6.00000000
-70.22485	42.07595	3	Low Cliff	1.7287	2.78590	1.895	1.20	0.9847	3	1	3	3	4	2	6.00000000
-70.20815	42.07595	4	Low Cliff	1.1136	2.78590	1.895	1.20	0.7759	3	3	3	3	4	2	10.39230484
-70.19145	42.07595	5	Low Cliff	0.9970	2.78590	1.895	1.20	-0.0103	3	3	3	3	4	2	10.39230484
-70.17475	42.07595	6	Low Cliff	1.2001	2.78590	1.895	1.30	-0.4071	3	2	3	3	5	2	9.48683298
-70.15805	42.07595	7	Low Cliff	1.4314	2.78590	1.895	1.30	0.1950	3	2	3	3	5	2	9.48683298
-70.14135	42.07595	8	Low Cliff	1.5738	2.78590	1.895	1.30	-0.2147	3	2	3	3	5	2	9.48683298
-70.12465	42.07595	9	Low Cliff	1.5086	2.78590	1.895	1.30	-0.2740	3	2	3	3	5	2	9.48683298
-70.24155	42.07595	10	Low Cliff	3.8527	2.78590	1.895	1.10	0.9734	3	1	3	3	4	2	6.00000000

$$CVI = \frac{\sqrt{a * b * c * d * e * f}}{6}$$

where a = geomorphology,
b = shoreline erosion/accretion rate,
c = regional coastal slope,
d = relative sea-level change,
e = mean significant wave height,
and f = mean tidal range

Outline

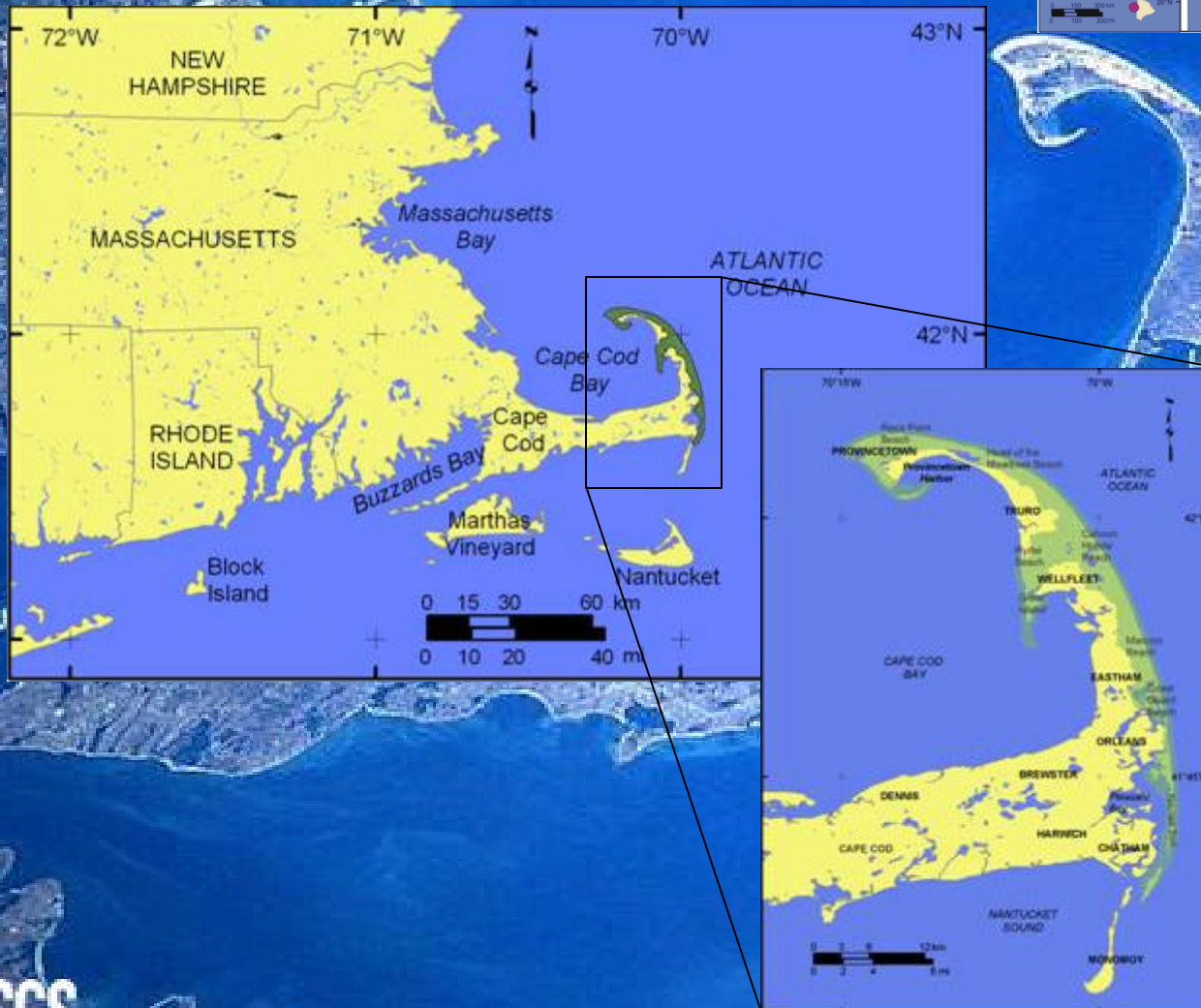
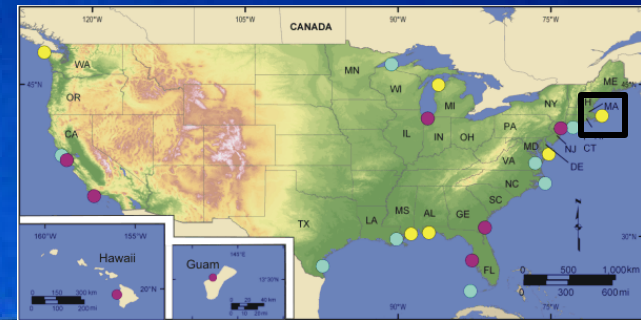
CVI Methods

Parks:

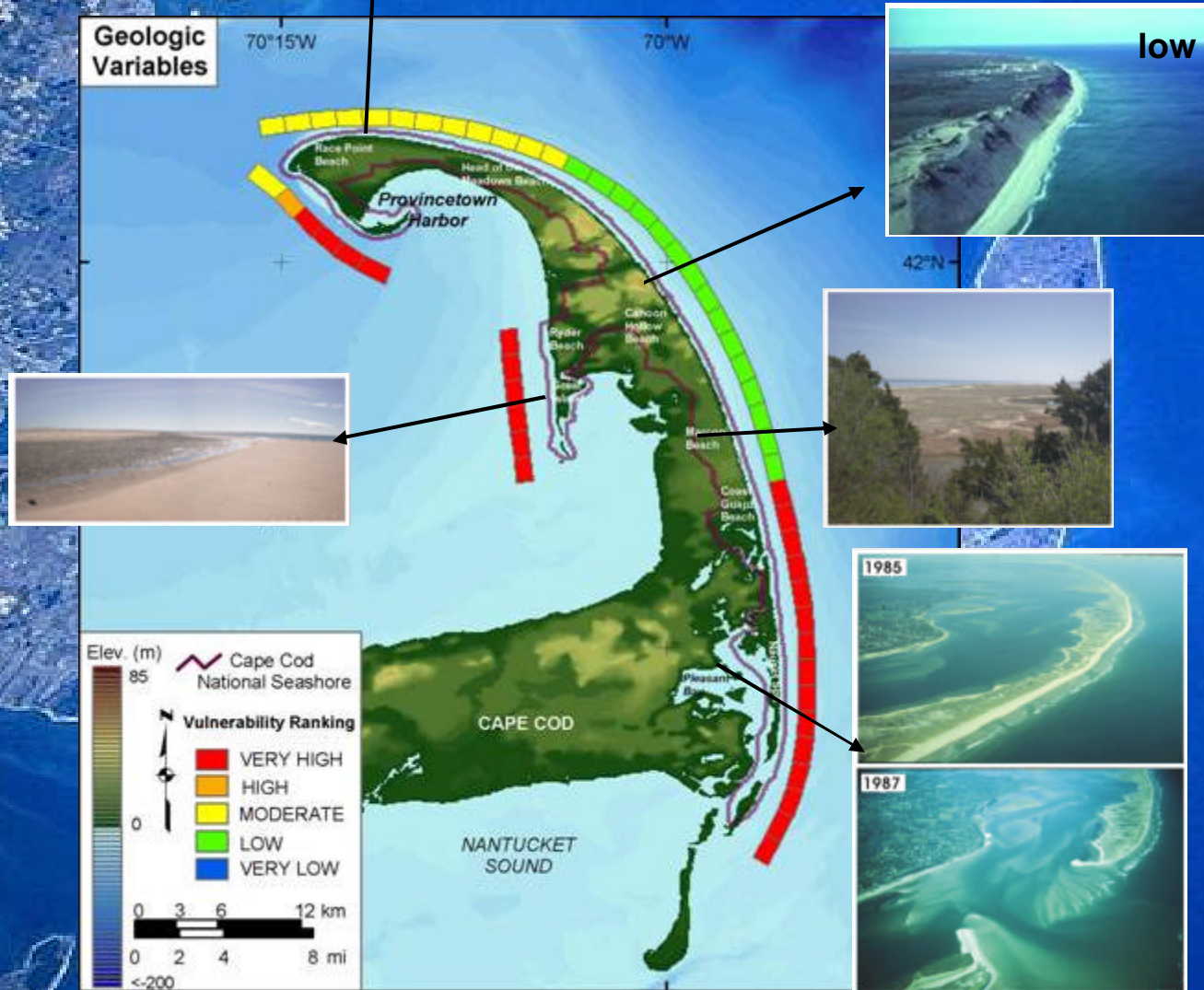
- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

Digital Products

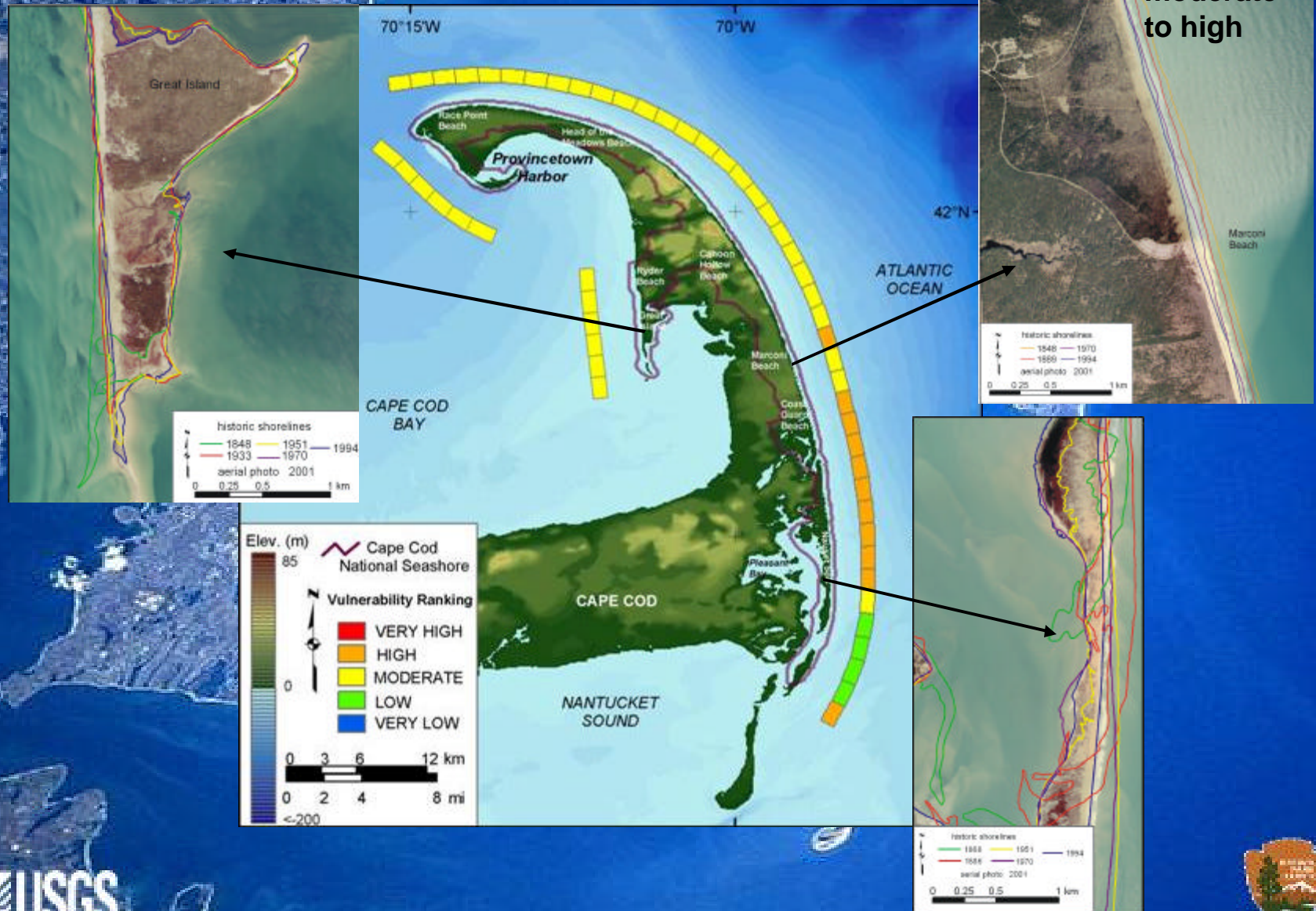
Cape Cod National Seashore (CACO) Located in Massachusetts



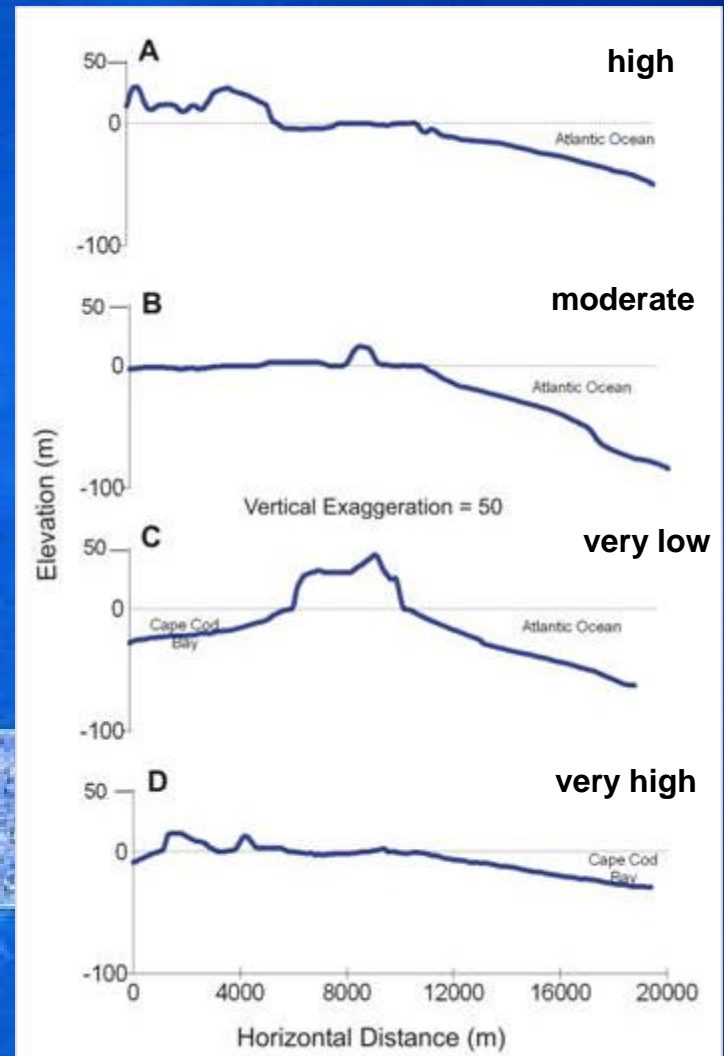
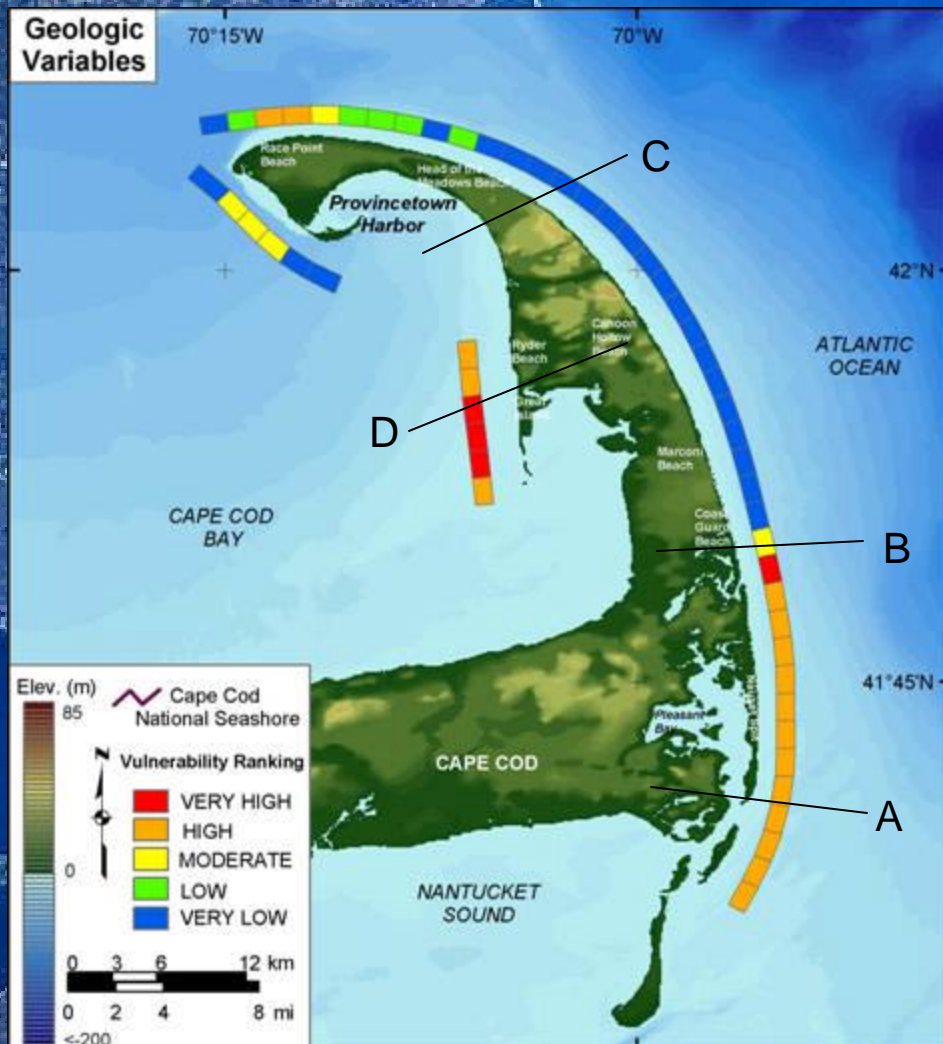
Geomorphologic Vulnerability for CACO



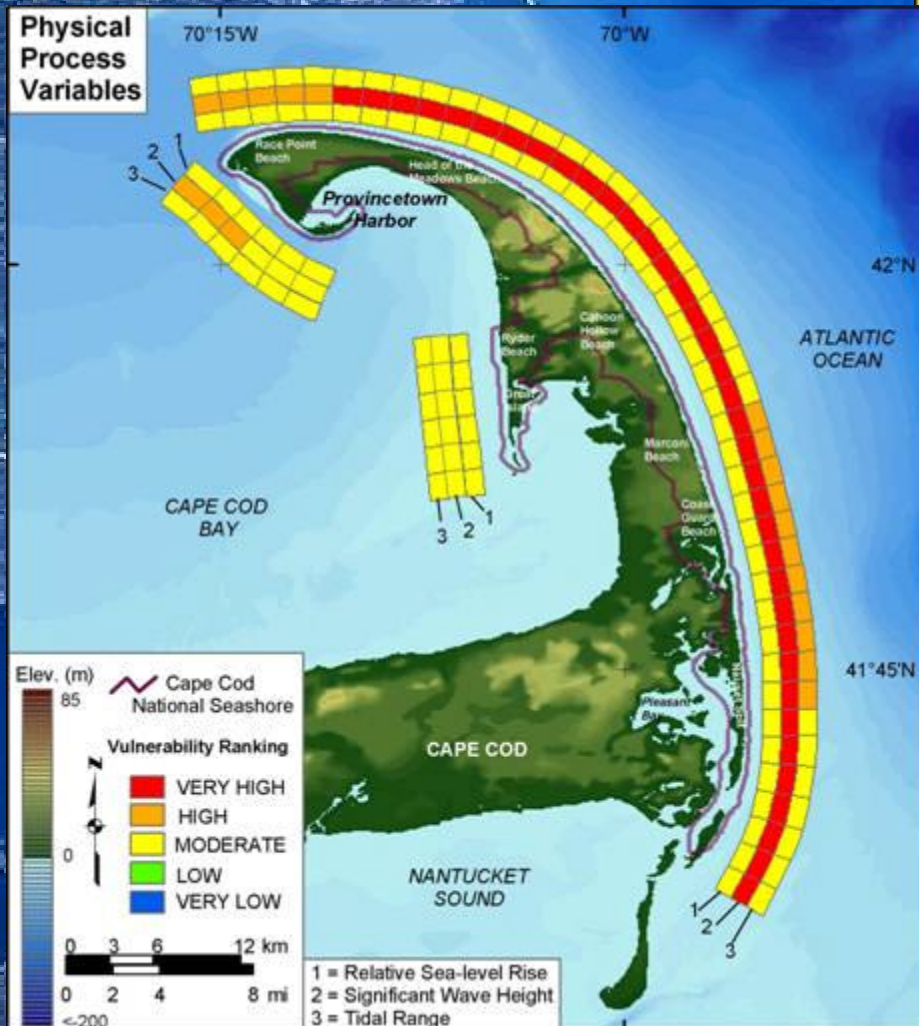
Shoreline Change Vulnerability for CACO



Regional Coastal Slope Vulnerability for CACO



Physical Process Variables for CACO



CVI Assessment for CACO

Relative Coastal Vulnerability

Physical Process Variables

Geologic Variables

CVI

CAPE COD BAY

CAPE COD

NANTUCKET SOUND

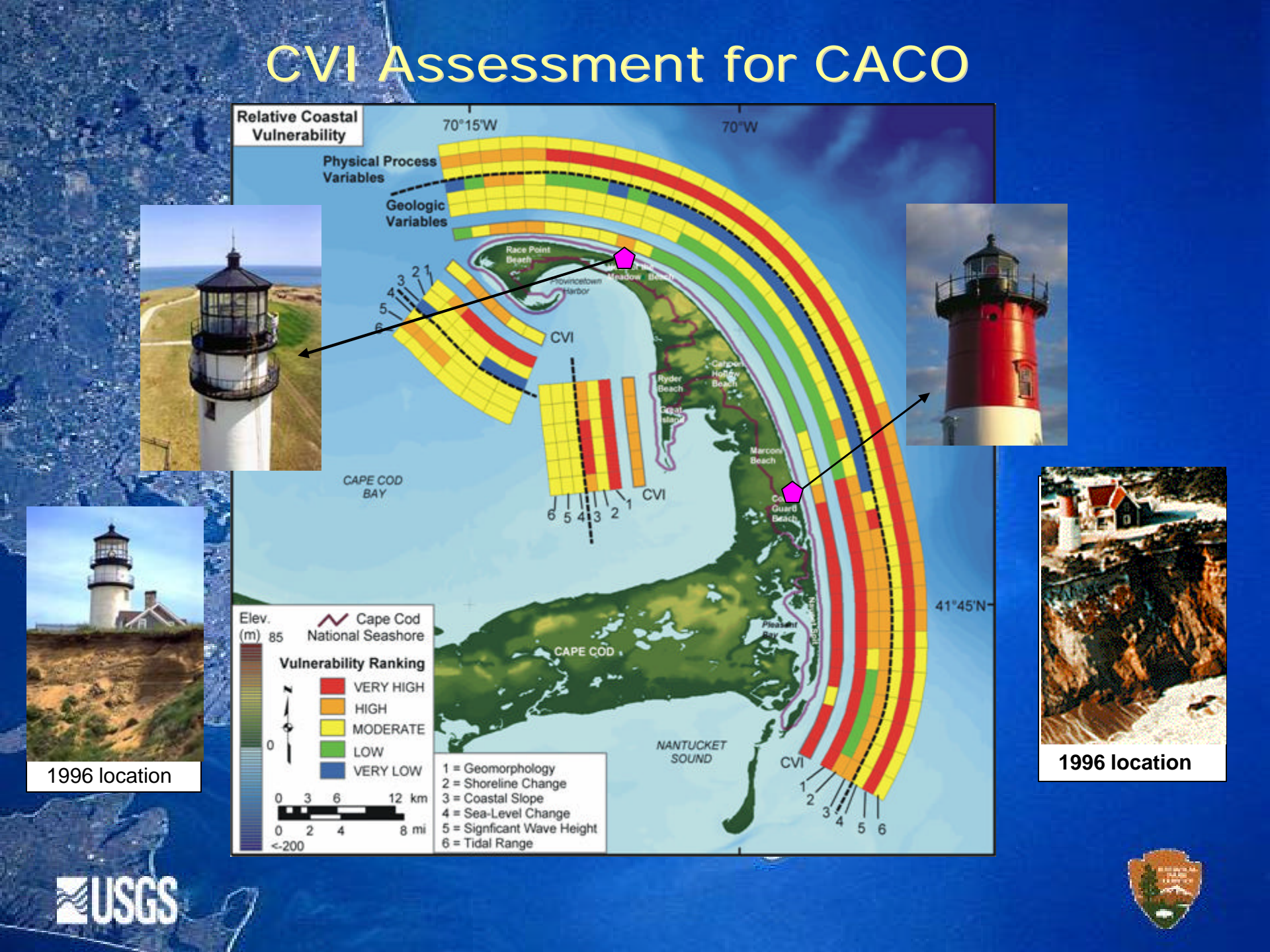
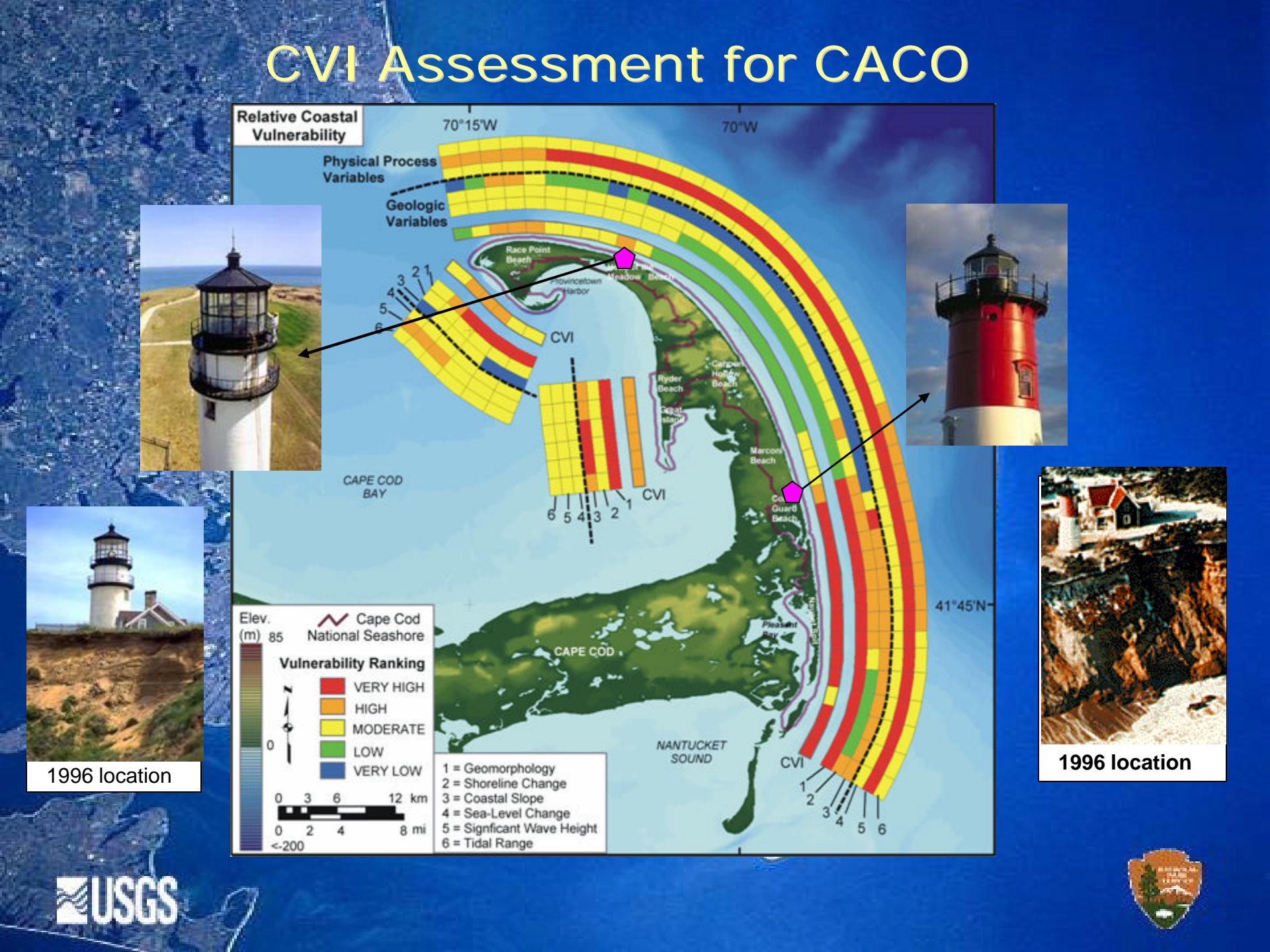
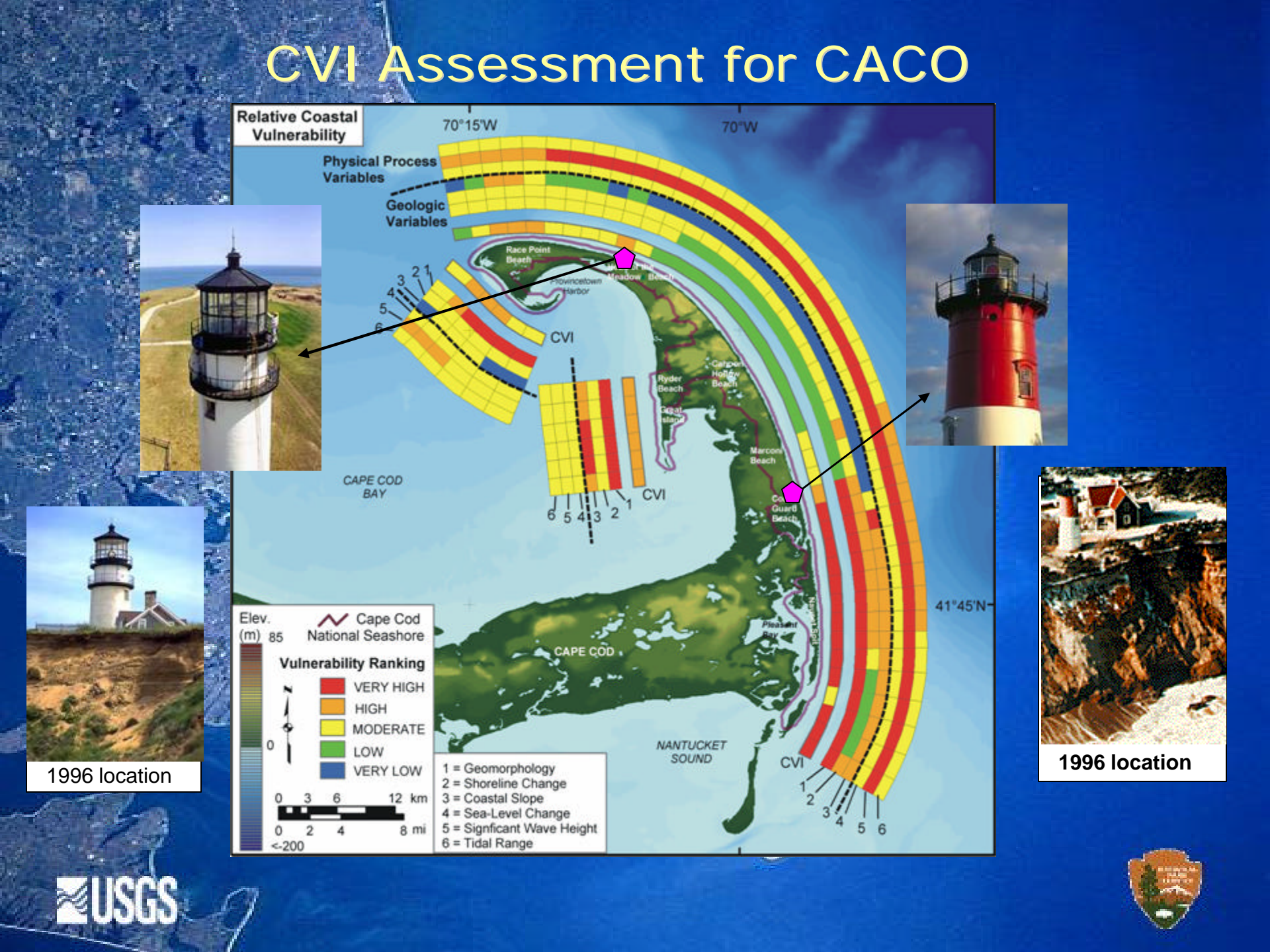
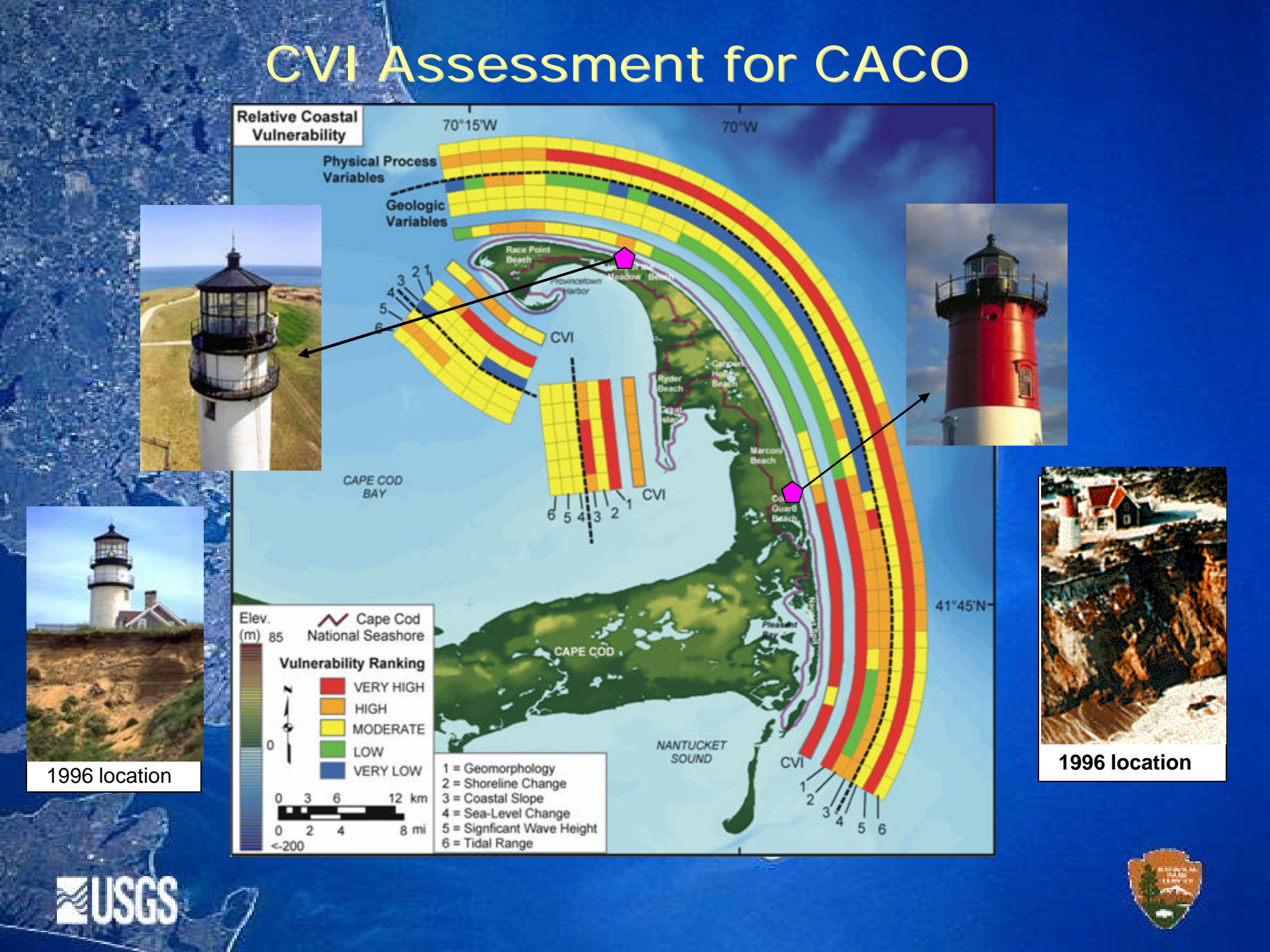
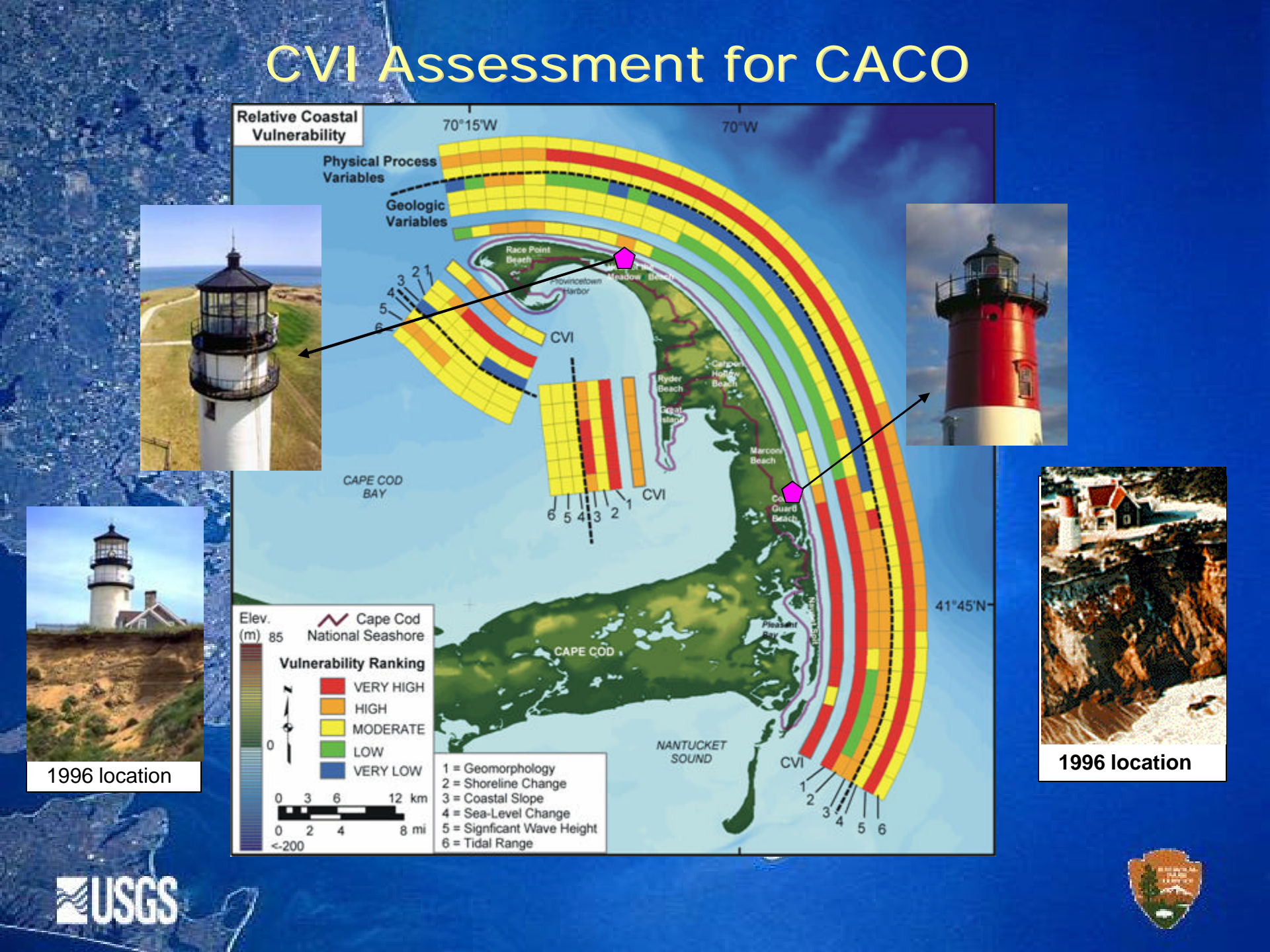
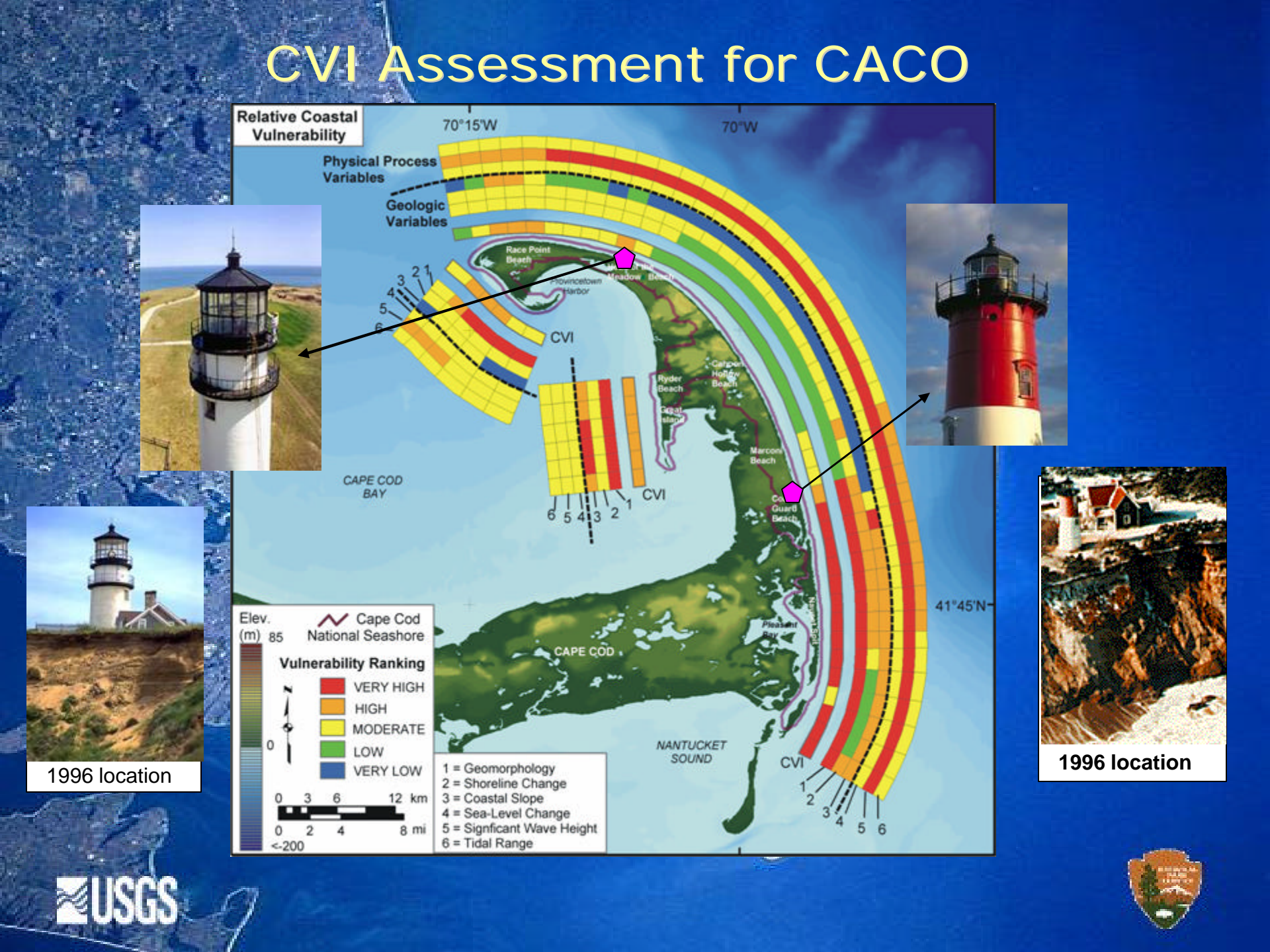
1996 location

1996 location

USGS

1996 location

1996 location

[illegible][illegible]

Outline

CVI Methods

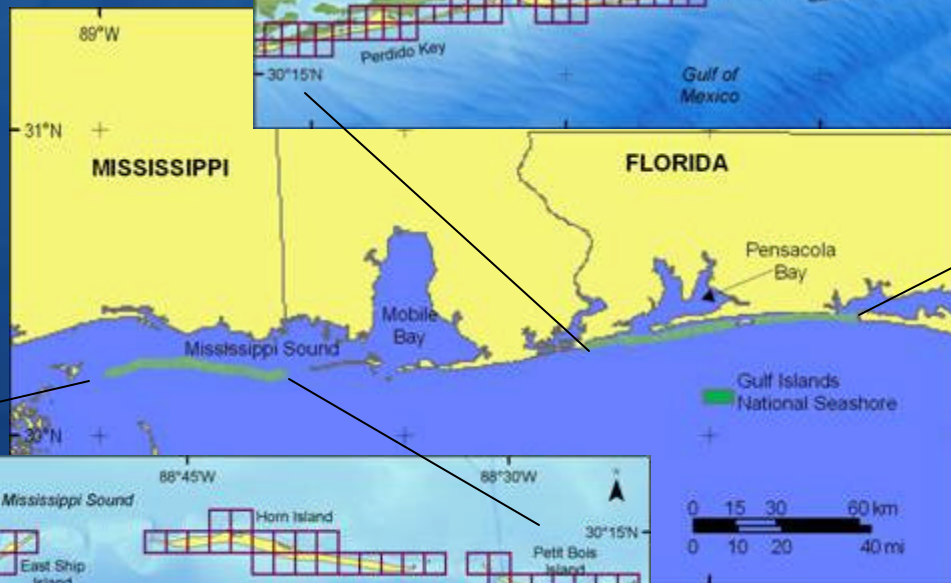
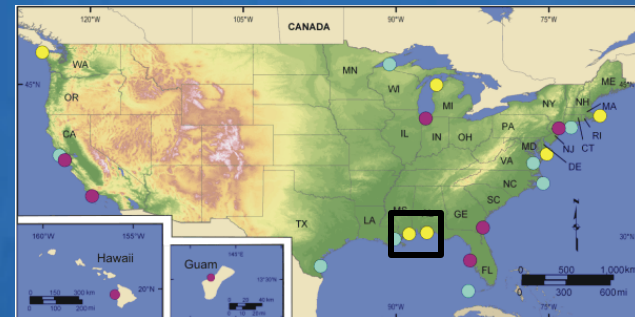
Parks:

- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

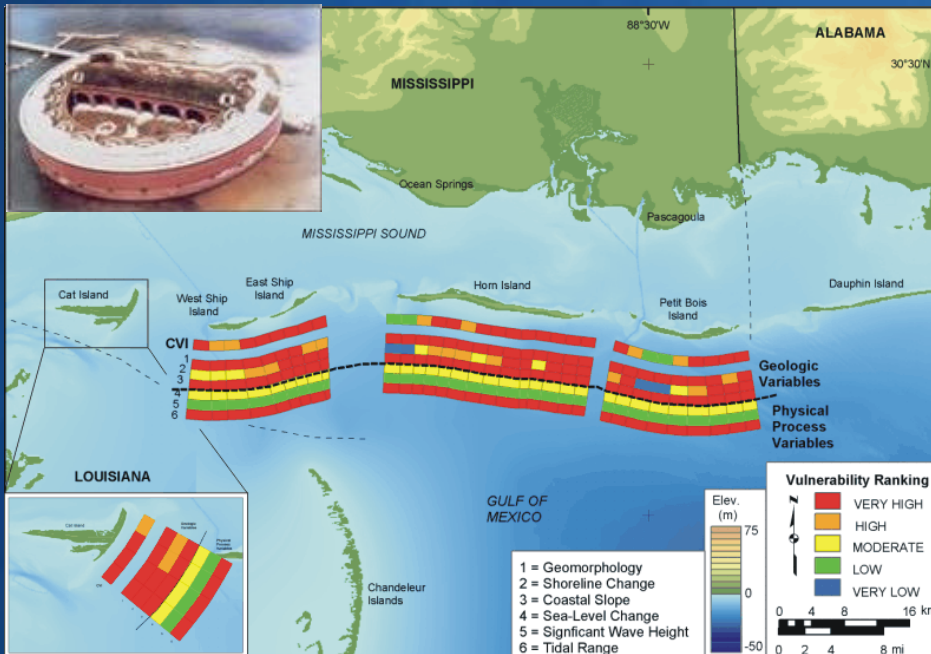
Digital Products

Gulf Islands National Seashore (GUIS)

Located in Florida and Mississippi



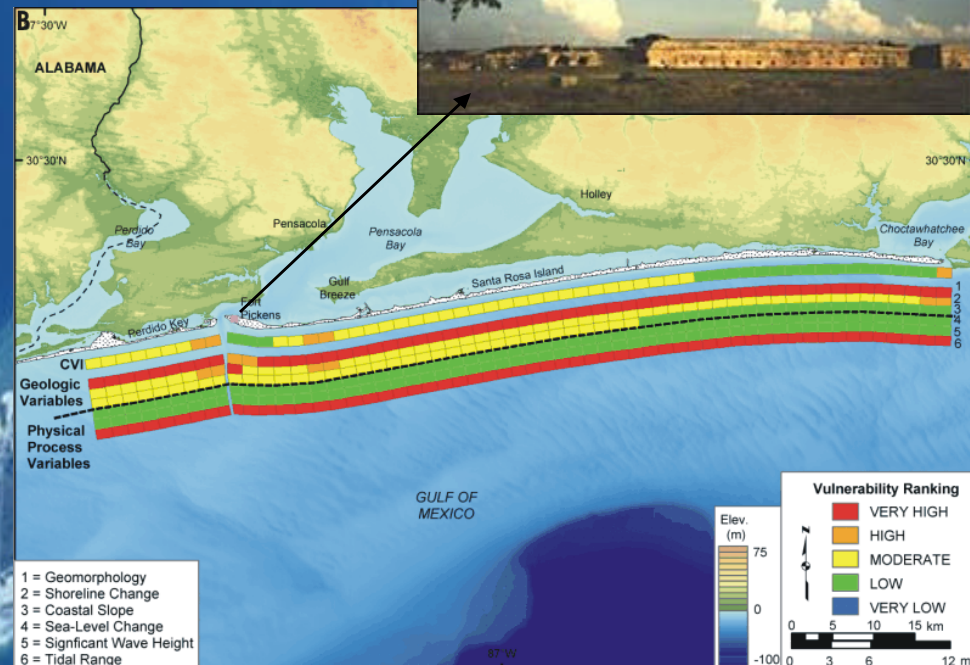
CVI Assessment for Gulf Islands National Seashore



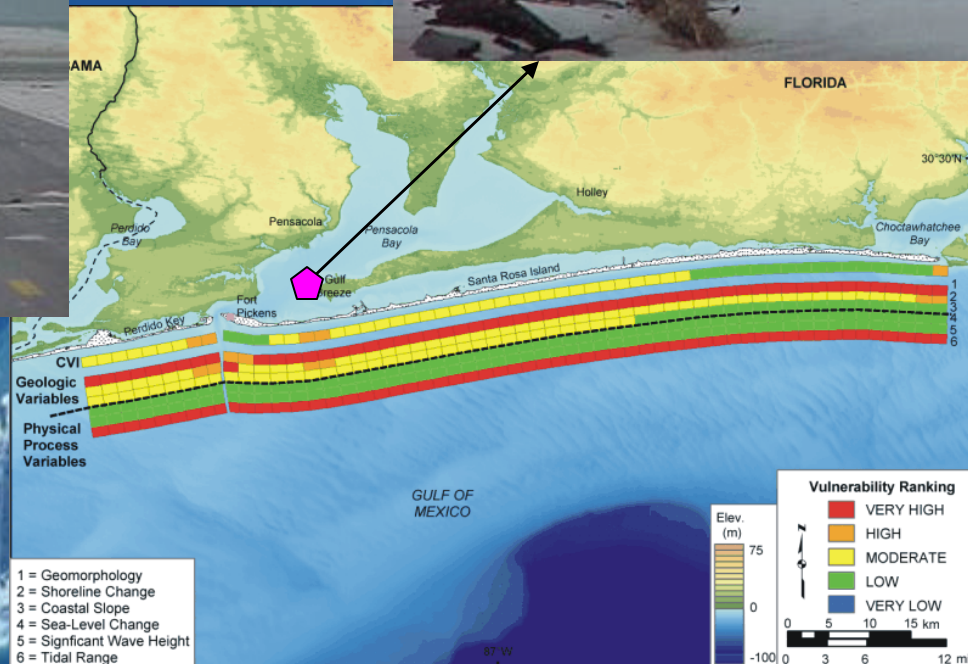
Fort Pickens on Santa Rosa Island (low vulnerability)



Fort Massachusetts On West Ship Island (high to very high vulnerability)



After Hurricane Ivan



Outline

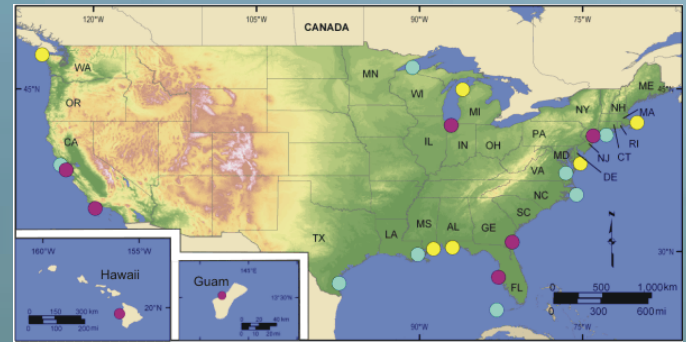
CVI Methods

Parks:

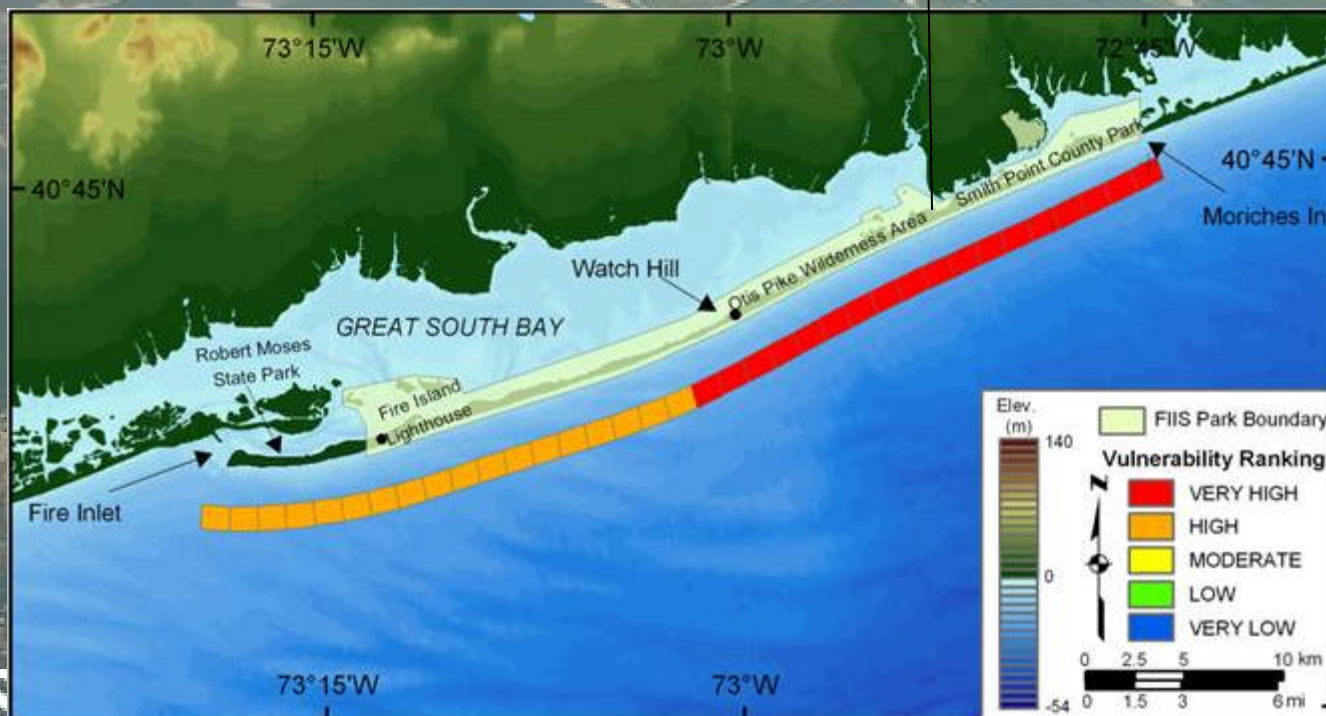
- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NS
- NP of American Samoa

Digital Products

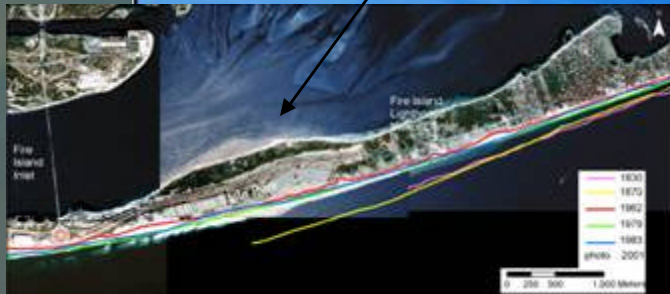
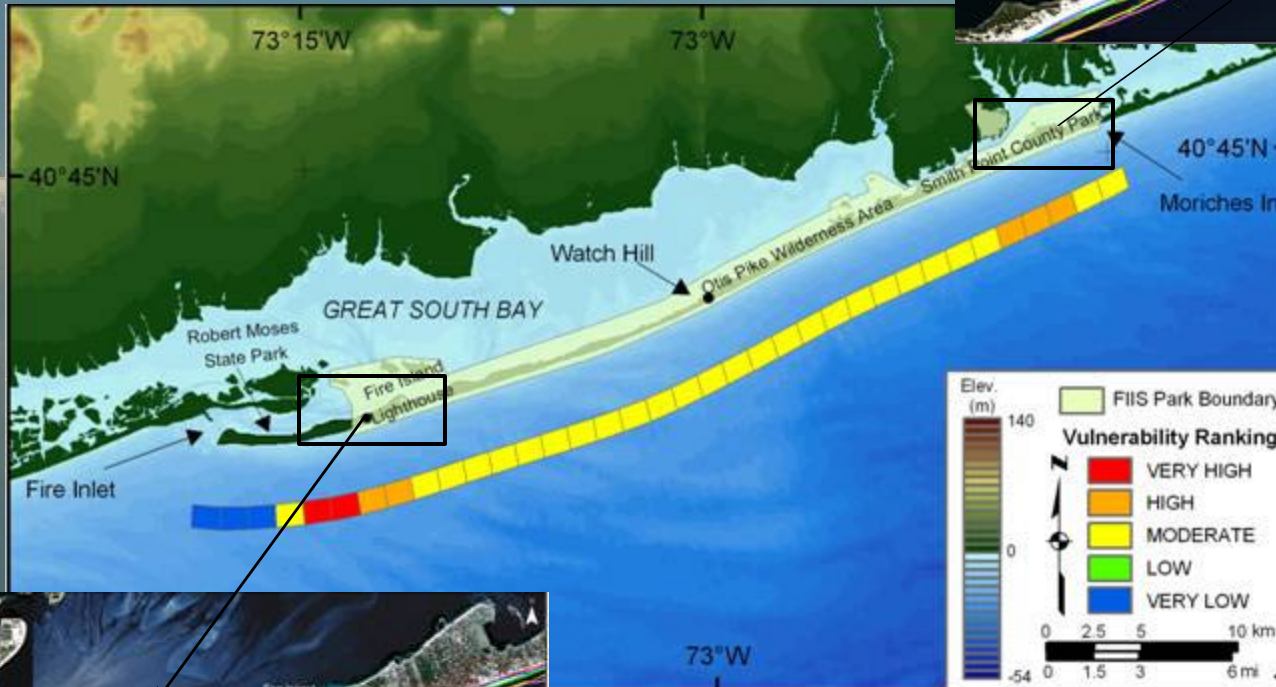
Fire Island National Seashore (FIIS) Located in New York



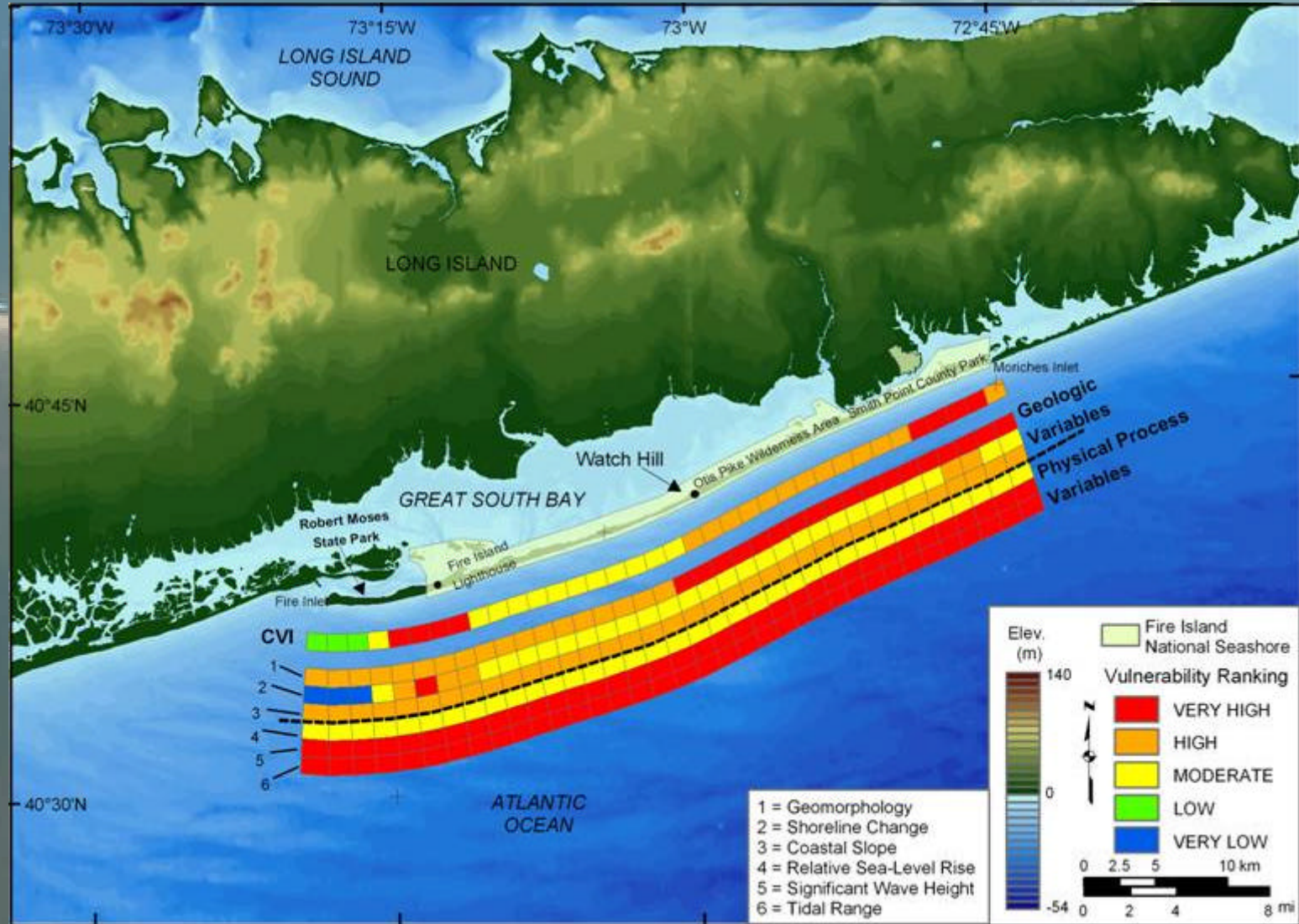
Geomorphologic Vulnerability for FIIS



Shoreline Change Vulnerability for FIIS



CVI Assessment for FIIS



Outline

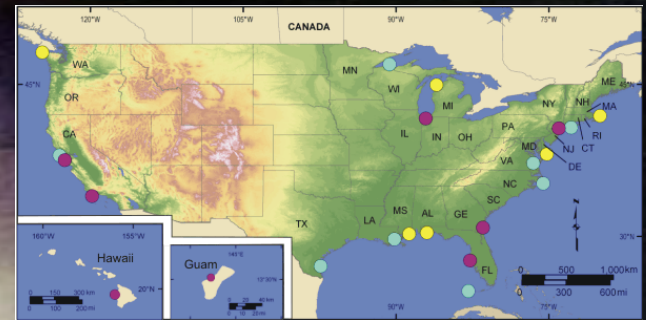
CVI Methods

Parks:

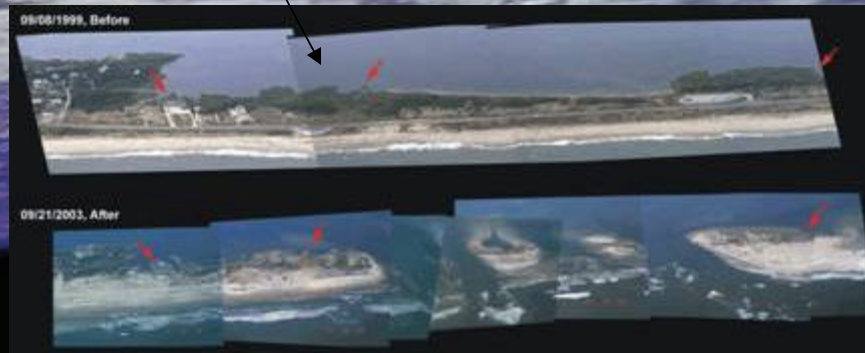
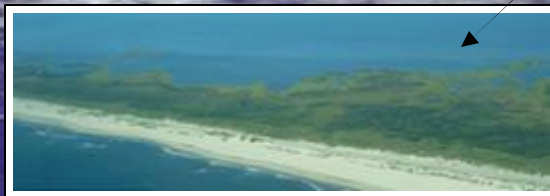
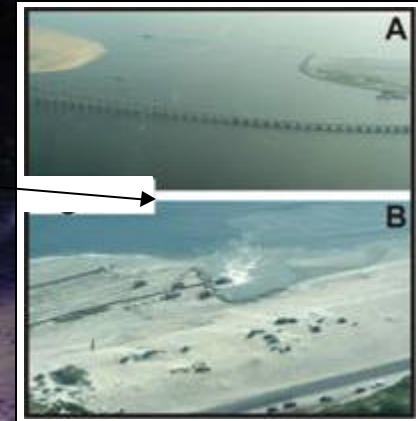
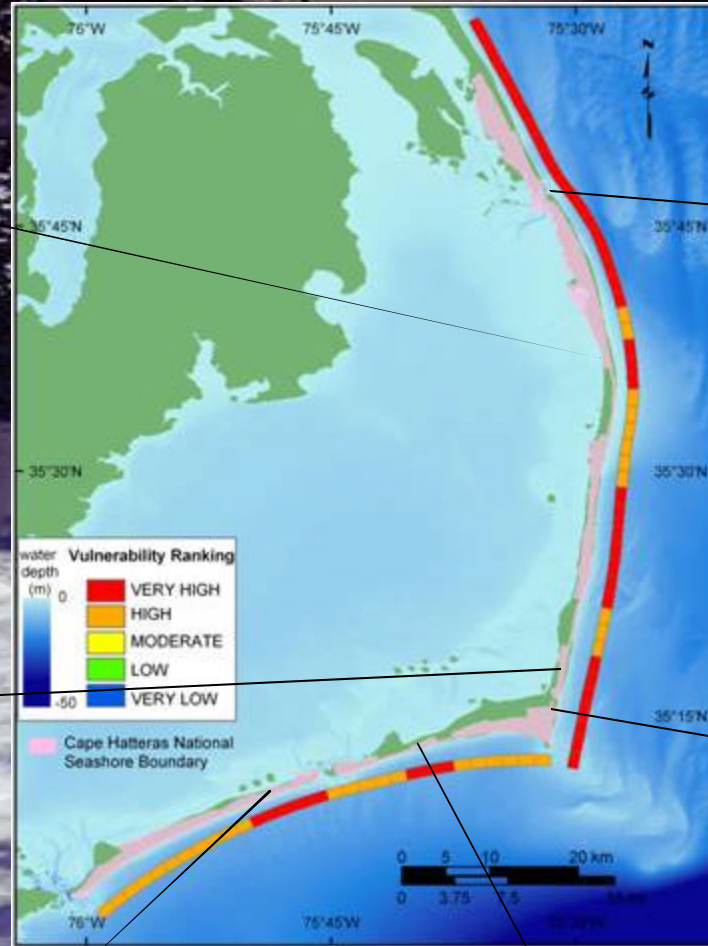
- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

Digital Products

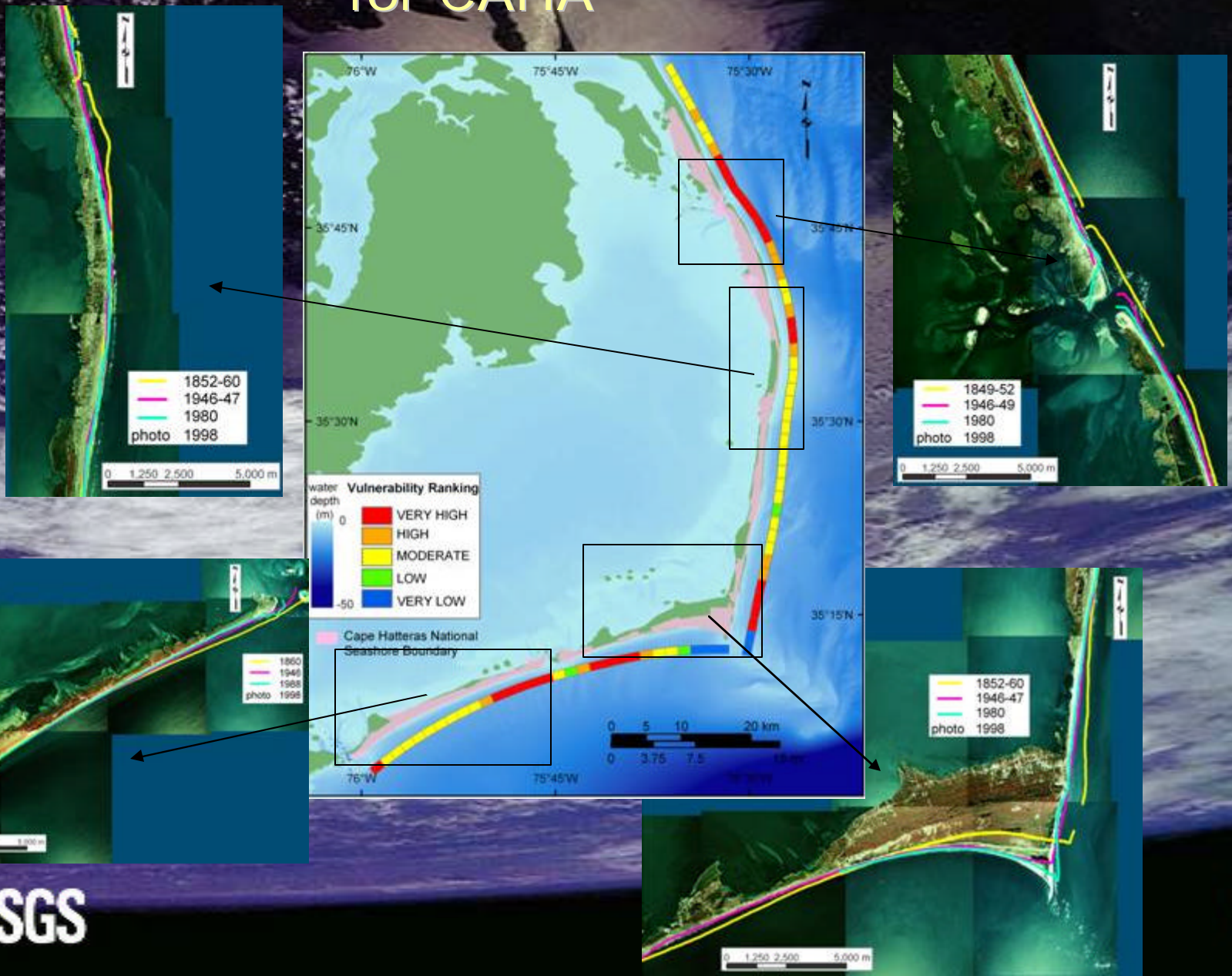
Cape Hatteras National Seashore (CAHA) Located in North Carolina



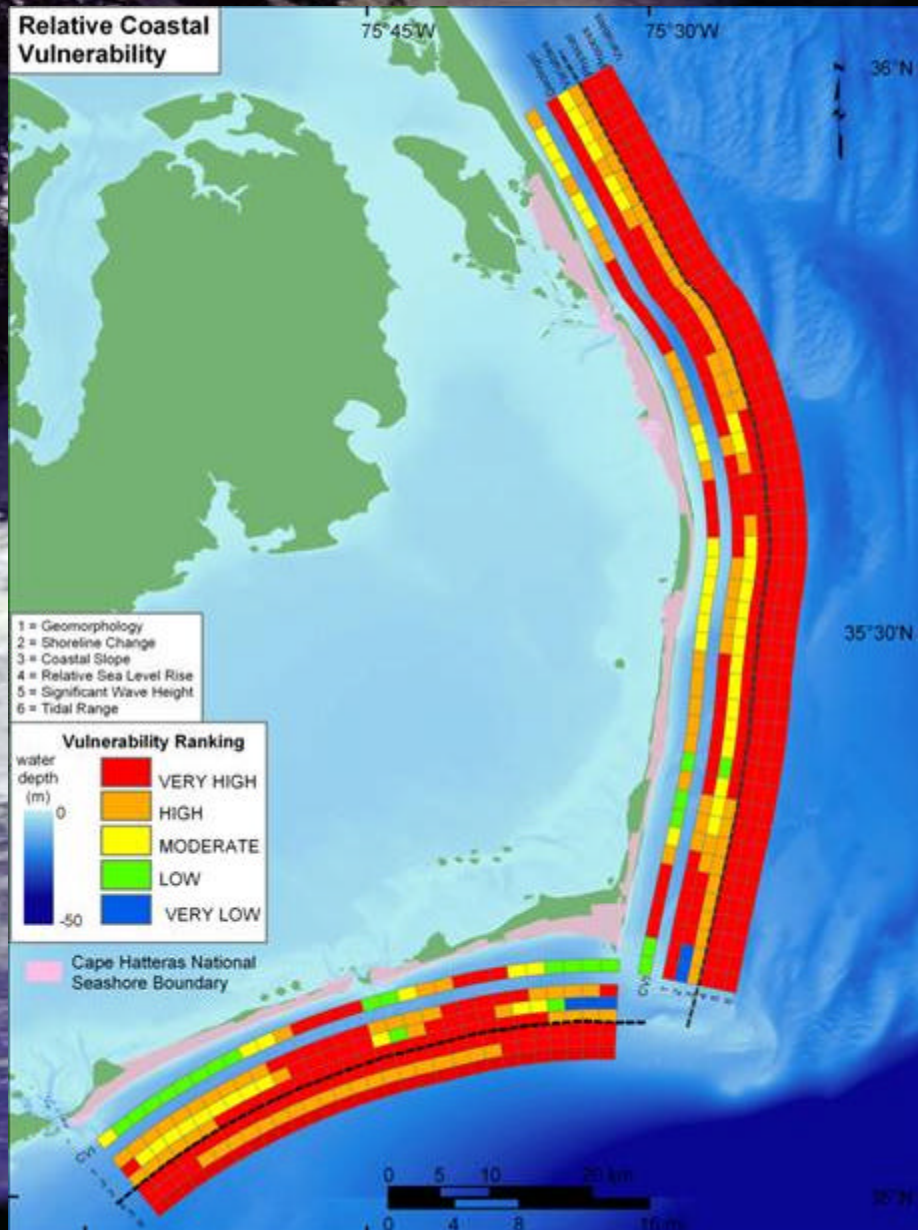
Geomorphologic Vulnerability for CAHA



Shoreline Change Vulnerability for CAHA



CVI Assessment for CAHA



Outline

CVI Methods

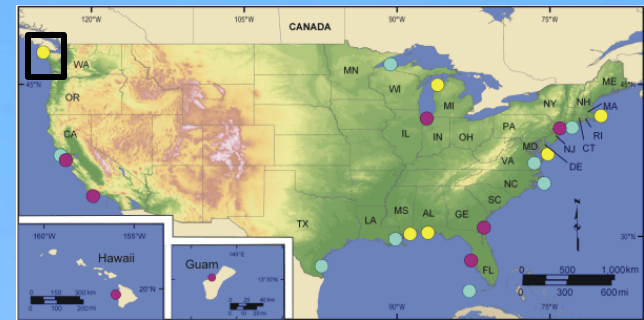
Parks:

- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

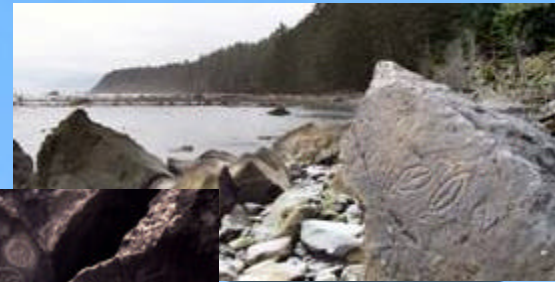
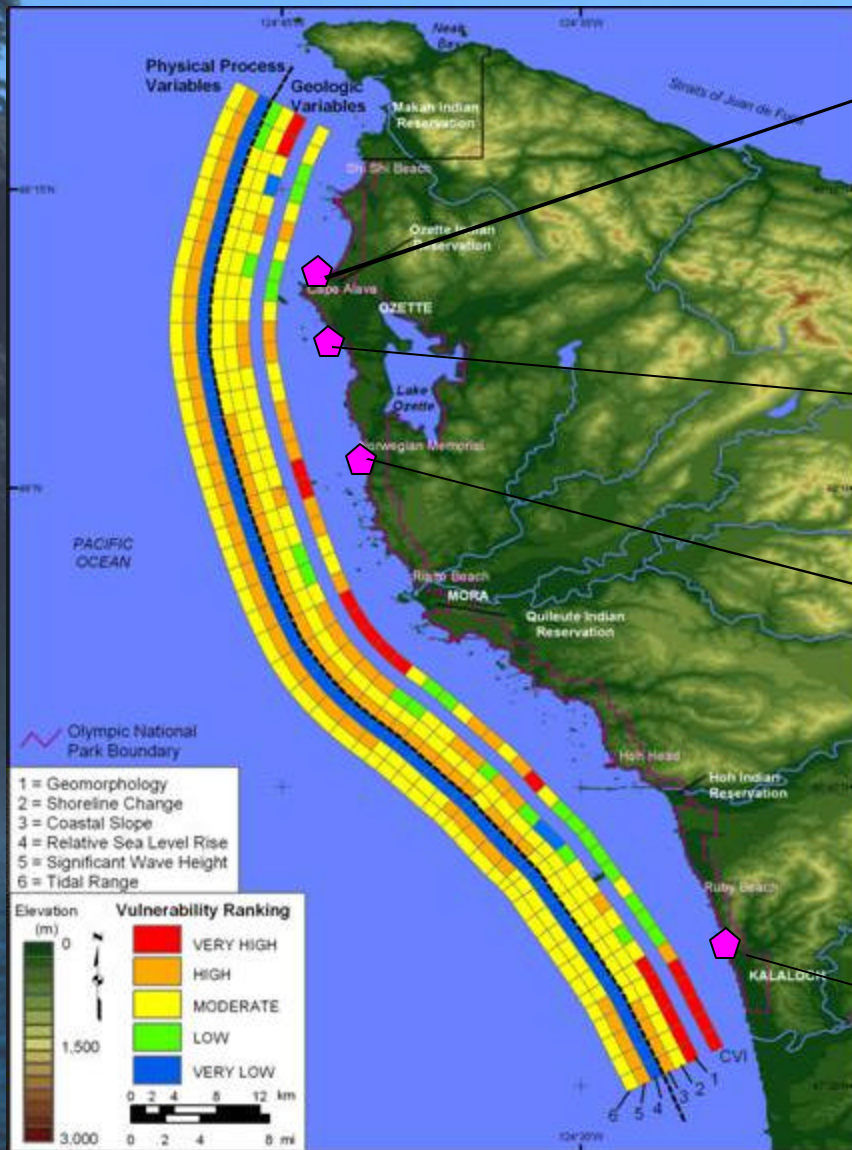
Digital Products

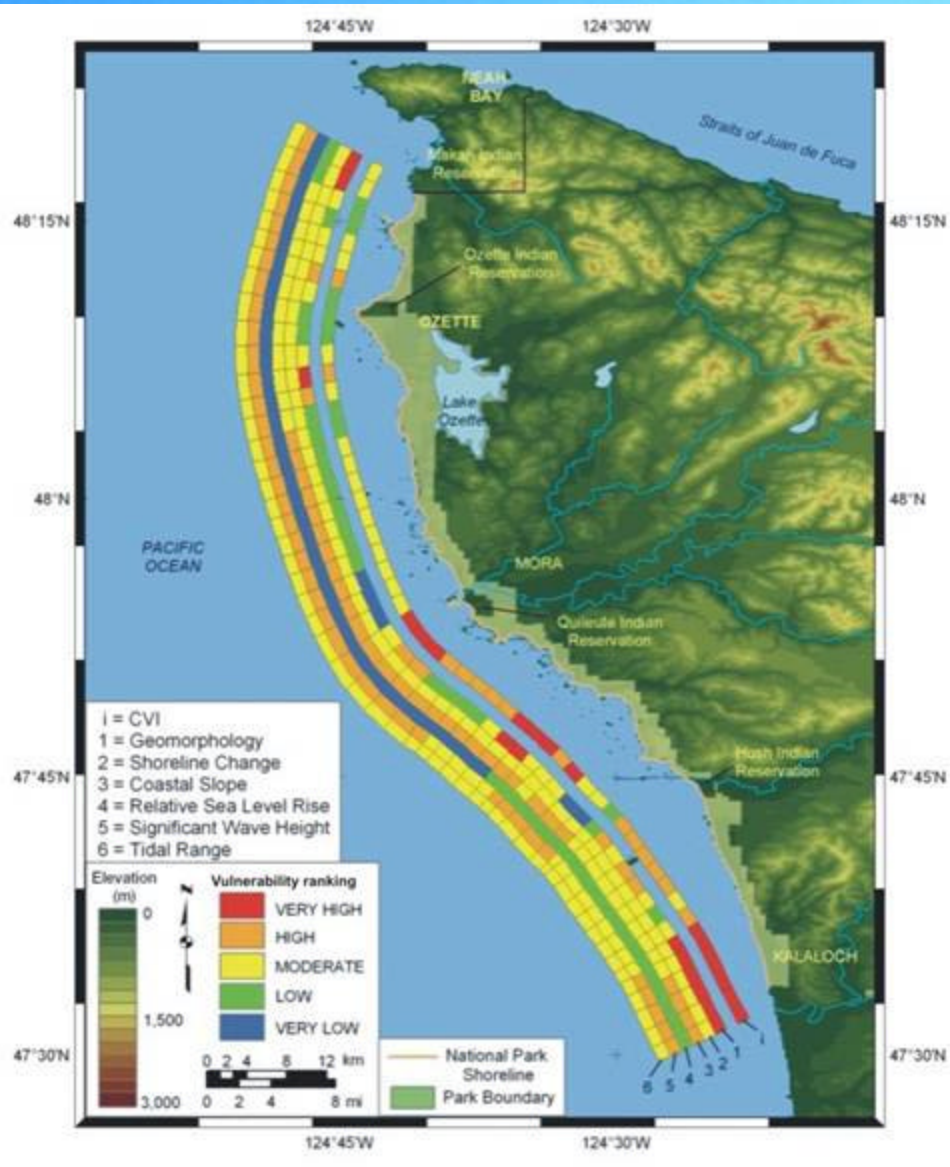
Olympic National Park (OLYM)

Located in Washington



CVI Assessment for OLYM





CVI Assessment for OLYM *used for GMP*



Outline

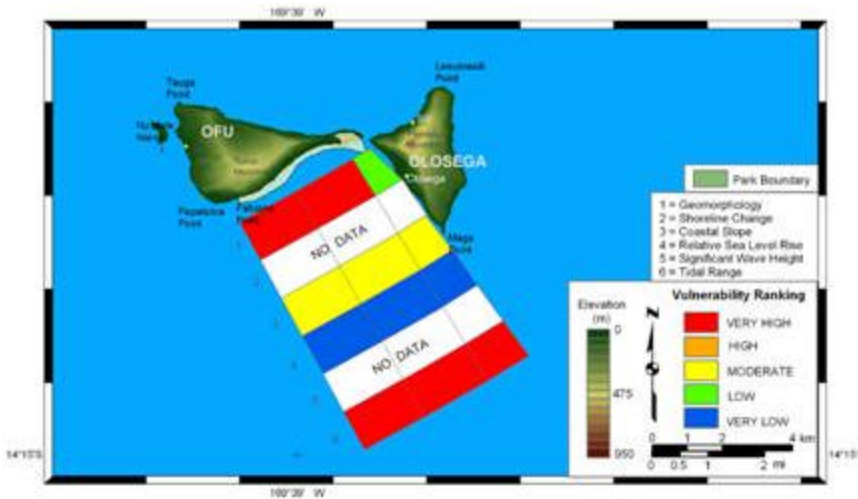
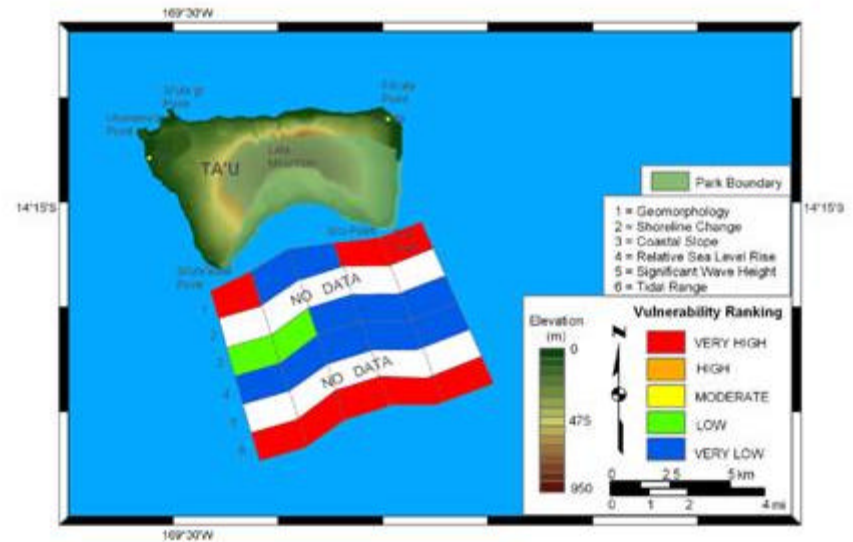
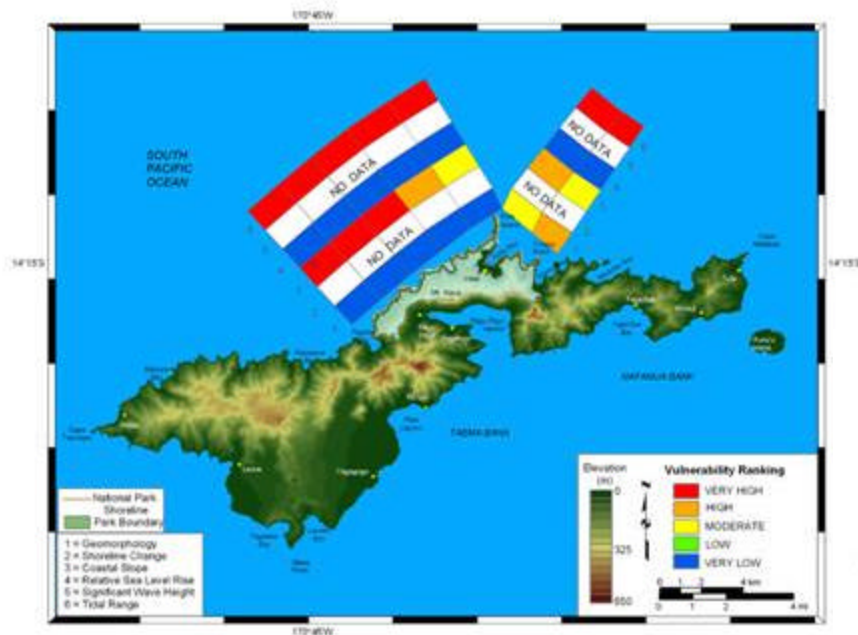
CVI Methods

Parks:

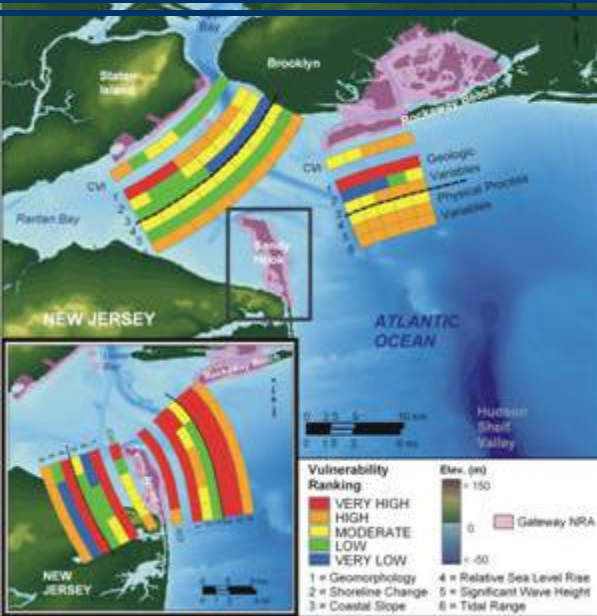
- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NP
- NP of American Samoa

Digital Products

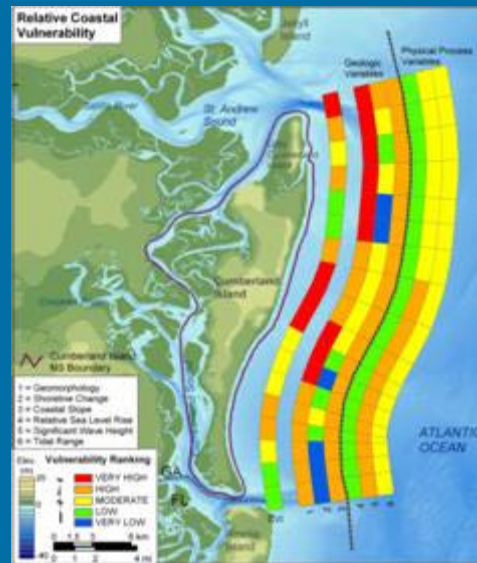
CVI Assessment for National Park of American Samoa



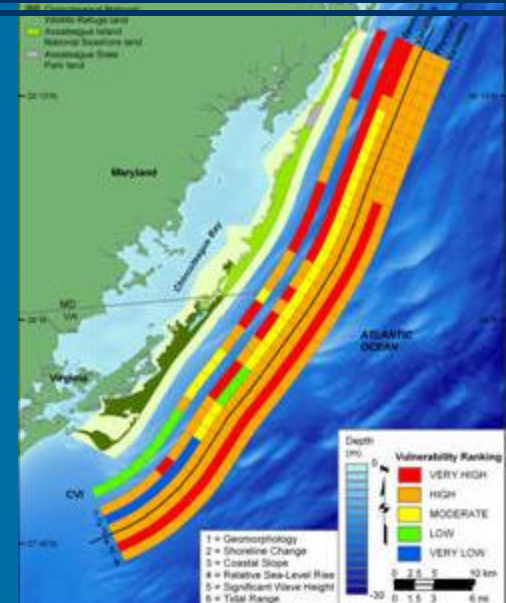
CVI Assessment for other National Park Units



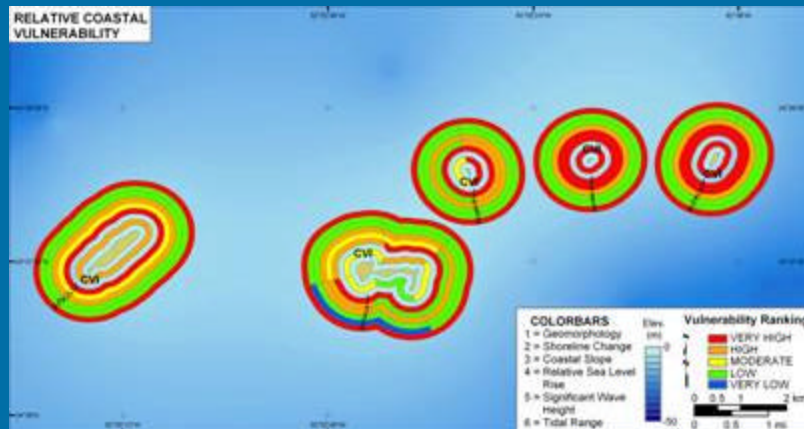
Gateway NRA



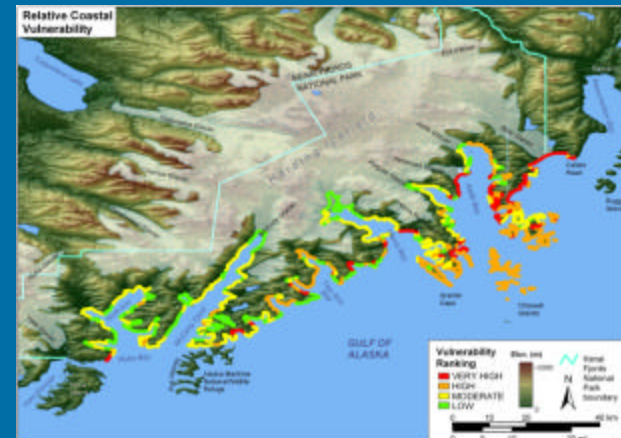
Cumberland Island NS



Assateague Island NS



Dry Tortugas NP



Kenai Fjords NP

CVI Project Summary

The results from this study can be used in at least two ways

- 1) To identify areas within the park where physical change as a result of sea-level rise may be most likely to occur
- 2) As a planning tool for managing and protecting resources within National Parks

Outline

CVI Methods

Parks:

- Cape Cod NS
- Gulf Islands NS
- Fire Island NS
- Cape Hatteras NS
- Olympic NS
- NP of American Samoa

Digital Products

Products

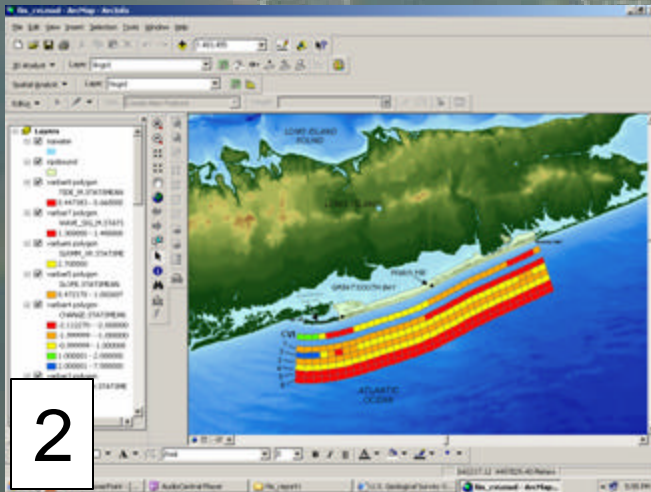
1) Open File Report in Electronic Book Format

2) Shapefiles and project files used in analysis with metadata

1



2



CVI website

<http://woodshole.er.usgs.gov/project-pages/nps-cvi/>



[USGS Coastal & Marine Program](#)

[USGS Woods Hole Science Center](#)



Relative Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise

Project Description

The National Park Service (NPS) is responsible for managing nearly 12,000 km (7,500 miles) of shoreline along oceans and lakes. In 2001 the U.S. Geological Survey (USGS), in partnership with the NPS Geologic Resources Division, began conducting hazard assessments of future sea-level change by creating maps to assist NPS in managing its valuable resources. This website contains results of the coastal vulnerability index (CVI) assessment for several national park units, highlighting areas that are likely to be most affected by future sea-level rise.

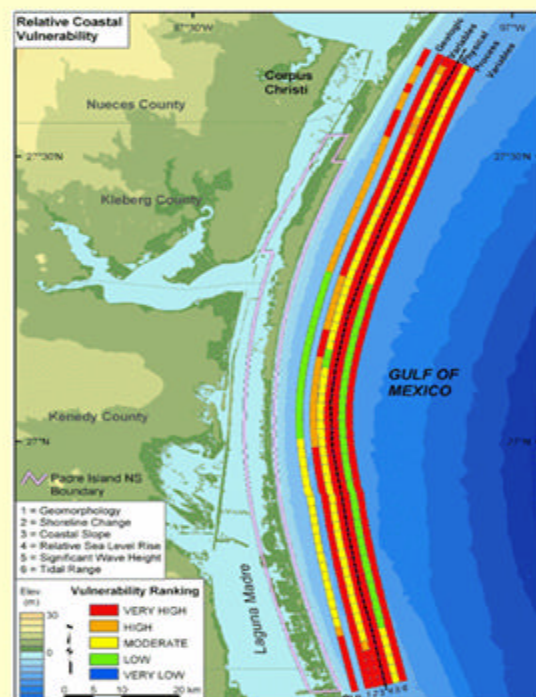
Through the use of a CVI, the likelihood that physical changes will occur as sea-level rises is quantified based on the following criteria: tidal range, wave height, coastal slope, shoreline change, geomorphology, and historical rate of relative sea-level rise. This approach combines a coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, and yields a relative measure of the system's natural vulnerability to the effects of sea-level rise. National Park Service staff are using the CVI data for long-term resource management plans, park facilities planning such as relocating building or roads, and assessing long-term threats to resources.



Relative Coastal Vulnerability Assessment of Padre Island National Seashore (PAIS) to Sea-Level Rise

Elizabeth A. Pendleton, E. Robert Thieler, S. Jeffress Williams, Rebecca S. Beavers

COMING SOON USGS Open-File Report 2004-1090



- Title
- Abstract
- Introduction
- Data Ranking System
- Cumberland Island National Seashore
- Methodology
- Geologic Variables
- Physical Process Variables
- Calculating the Vulnerability Index
- Results
- Discussion
- Conclusions
- References

COASTAL VULNERABILITY ASSESSMENT OF CUMBERLAND ISLAND NATIONAL SEASHORE (CUI) TO SEA-LEVEL RISE

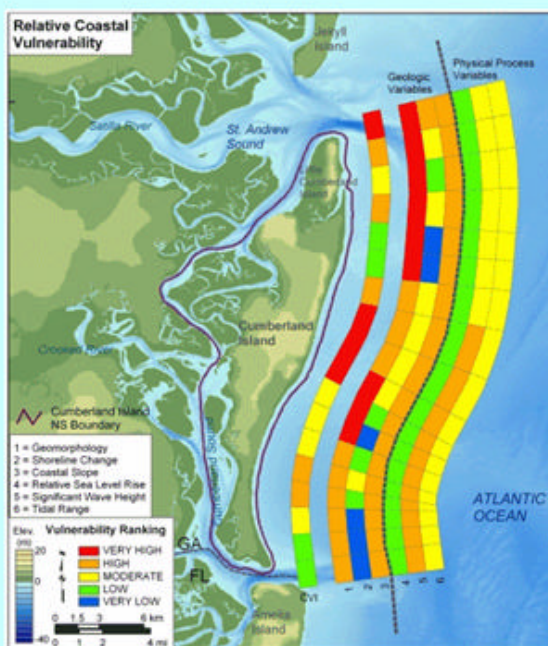


Figure 5. Relative Coastal Vulnerability for Cumberland Island National Seashore. Click on figure for larger image.

CVI website

<http://woodshole.er.usgs.gov/project-pages/nps-cvi/>